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NOTES AND COMMENTS.

Moulding Sand.

In the contributed discussion on Mr. A. E. Outerbridge's paper on the above subject, published in the proceedings of the American Society of Mechanical Engineers, Mr. H. M. Lane says, "Mr. Mumford has brought out a point in regard to rubbing the alumina into the sharp silica to make the sand stronger which reminds me of a recent experience at a foundry in Ohio.

"The foundryman was using a sharp, bank sand, mixed with a small amount that contained a little natural bond and a certain amount of core binder—a dry binder in this case—and had been discarding 50 per cent. of the core sand and using about 15 to 20 per cent. of the natural bond to make the mixture strong enough. He designed and put in a mill, which was essentially a clay grinding mill, and now grinds his core material, using 90 per cent. of the old core sand. He finds that in the large cores the binder in the interior of the cores does not become so badly burned out, but that it still retains a great deal of bonding quality, so that he now uses only half of the binder. He has thrown out all of the expensive imported sand and uses the local bank sand. He formerly had a power riddle and four men working all day to supply his foundry with core sand. To-day he has a night force to haul the sand out, as formerly, but he has two men working less than half a day to supply the entire foundry with core sand. He formerly had to wheel the burnt core sand some 450 ft. away from the foundry and dump it over the bank. Now he wheels it through a partition into the next room.

"In regard to the Worthington practice of grinding the bond in thoroughly, they found that they got the bond on the corners of the sand, if I may so express it, thus giving a very porous core, while if it was mixed in by hand they got a much

denser core. In other words, the venting of pockets and chambers gave less trouble than formerly, because less compound was used and the pores were not being stopped up. They have been able to cast a great many very thin jackets in this way without any trouble at all, even though vent passages were cut."

Mr. E. H. Mumford says, "At a large foundry making steam pumps all the sand used in the smallest port cores is run through a mill, and with very good result. Nothing but raw linseed oil is used as a binder. The ratio of sand to binder is from 60 to 90 to 1. This very large ratio of sand to binder is entirely due to the rubbing in of the binder upon the small crystals of silica."

The Properties of Ferro-Silicon.

In the recently-issued annual report of the Chief Inspector of Factories and Workshops there appears a contribution by Mr. D. R. Wilson relative to the properties of ferro-silicon. He reports as follows:—

Ferro-silicon possesses explosive as well as poisonous characteristics. For this information I am indebted to Mr. Deby, chief chemist at Messrs. Cammell, Laird & Company, Limited, of Sheffield. Higher-grade ferro-silicon, although it has been known to chemists for many years, has only recently been prepared on the large scale for technical purposes. About 4,000 tons are imported annually into the United Kingdom from France and Germany, and to a less extent from other countries; little or none is prepared in England.

It is made by heating together iron ore, quartz, coke, and lime (as a flux) to an enormously high temperature in the electrical furnace; the coke reduces the quartz and ore to silicon and metal, with the production of ferro-silicon containing up to 80 per cent. silicon. It is generally packed in iron drums or casks for export. Certain kinds of ferro-silicon seem to be decomposed or rather disintegrated into powder by the action of moist air; this apparently is not dependent on the proportion of silicon present, as specimens containing up to 80 per cent. silicon have been found to remain unchanged for weeks.

Its poisonous properties can be simply explained by the fact that it is liable to evolve phosphoretted and arseniuretted hydrogen in contact with moisture. The iron ore and quartz often contain phosphates, which in presence of carbon and at the high temperature of the electrical furnace would, no doubt, be converted into phosphides, combining with the lime to form calcium phosphide; in the same way, any arsenic present would yield calcium arsenide. These would be decomposed in presence of water and evolve phosphoretted and arseniuretted hydrogen, both of which possess powerful poisoning properties.

The explosions that have occasionally occurred are more difficult to explain, and several theories have been put forward. The properties of ferro-silicon indicate that considerable danger is connected with its transport, not only to persons on the ship, but to dock labourers engaged in unloading it at docks, and it is to be hoped that some authoritative pronouncement as to the cause of the danger and the means of avoiding it may be given in the near future. It appears that the presence of moisture is the cause of these accidents, and every effort should be made to ensure that the material is in a dry condition when packed, and that there is no possibility of moisture gaining access to the receptacles containing it.

British Foundrymen's Association.

A general meeting of the Sheffield and District Branch was held in the Department of Applied Science, the University, St. George's Square, on Saturday evening, November 21, when Mr. Percy Longmuir, B.Met., Carnegie Medallist, read a paper on "Alloys." The President, Mr. Herbert Pilkington, M.I.C.E., occupied the chair.

Manchester Branch.

We draw our readers' attention to the change in the secretaryship of this Branch of the British Foundrymen's Association. Mr. H. Sherburn, Rotherwood, Stockton Heath, Warrington, now occupies the position.

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Mr. L. Motley has acquired the plant, goodwill, etc., of Motley & Green, Limited, St. George's Iron Works, Kirkstall Road, Leeds.

The application of Mr. D. Smith, who had traded as an engineer and ironfounder in Wolverhampton, for his discharge in bankruptcy has been refused.

The Junior Institution of Engineers have forwarded to us the November number of their "Journal and Record of Transactions," containing an interesting paper, and the discussion following on "Hydraulic Plate-cutting and Riveting Machines."

FIG. 1.

THE HANDLING OF PIG-IRON ON THE CASTING BED.

ALTHOUGH casting machines for pig-iron have been perfected for some five years or more, the old-established practice of moulding on pig beds is still commonly followed in England. For an output not exceeding 700 tons per week it will doubtless continue in use. Those works which run a large proportion of the metal direct into pipes and other castings, and into mixers for steel-making, should always have a pig bed for emergency requirements. However, for a tonnage exceeding 700 tons per week, some form of casting machine has been adopted at several English works for dealing with an increased output of iron. So far, however, its use has been very limited. The New Conveyor Company's machine, or the apparatus designed by Mr. Hawdon, appear to meet the principal requirements of a modern plant, and their use effects a considerable reduction in the wages bill under certain conditions. Certain improved methods of handling the output of a furnace are, however, becoming common, to the exclusion of casting machines. One of these is the increased use of cranes over the pig beds. In the Middlesbrough district especially the gantry pig bed crane has become a favourite. Following the example of the Skinningrove Iron Company, who were the pioneers, cranes have been put up at the works of the Normanby Iron Company, Cochrane & Company, Limited, and others. The crane at Messrs. Cochrane's works is shown in Fig. 1.

Fig. 2 shows a Royce 3-motor 3-ton electrically-driven overhead travelling crane erected over the pig casting beds of Messrs. James Dunlop & Company, Clyde Iron Works, Tolcross, near Glasgow. This crane has the unusually high longitudinal speed of 560 ft. per minute. The track being a long one, and the pig breaking machine at one end, the crane has to carry the pig-combs a considerable distance, and in consequence has been designed to start and accelerate up to full speed as quickly as possible, provision being made for pulling up rapidly and efficiently at the end of its journey by means of the Royce special reversible longitudinal drive. The span is 54 ft., and the length of the gantry is 425 ft. The height from the gantry rail to the

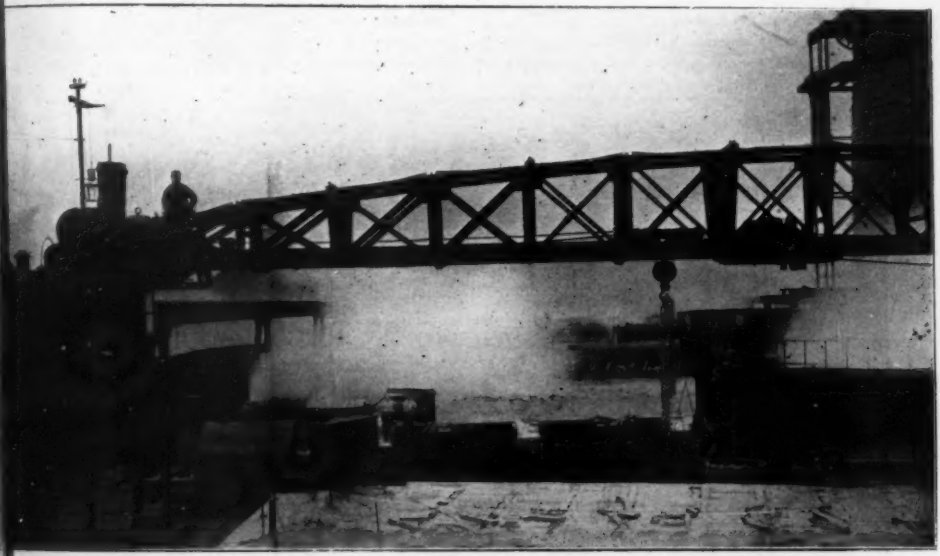

FIG. 1.—ELECTRIC CRANE AT THE BLAST FURNACES OF MESSRS. COCHRANE & CO., MIDDLESBROUGH: ADAPTED BY MESSRS. SCOTT & MOUNTAIN, LTD., NEWCASTLE ON-TYNE.

ground is 29 ft. The hoisting speed is 3 tons, at 36 ft. per minute, or, with light loads, hoisting at 70 ft. per minute is possible. The cross traversing, with 3 tons, is at the rate of 100 ft. per minute. The switches are of the reversible controller type, and all the motors are controlled from a cage or cabin. Combined roller and swivel bearings are fitted to the crab and the longitudinal travelling wheel axles.

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FOUNDRY SLAGS AND FLUXES.

THE importance of good slagging is recognised by all those daily engaged in literature on the subject of slags and fluxes, but the fact that, at the present time, the production and control of slags for various operations is one of such an uncertain and empirical character, is proof-positive of the ultra-theoretical nature of the investigations.

The truth is that the nature of slags as they exist, and their chemical and physical constitution is thoroughly understood; the production of the various silicates and aluminates (for slags are essentially such) under laboratory conditions is also understood, and even in the case of many practical workers on a large scale, it is thoroughly understood that if a certain metallurgical operation be accompanied by a given

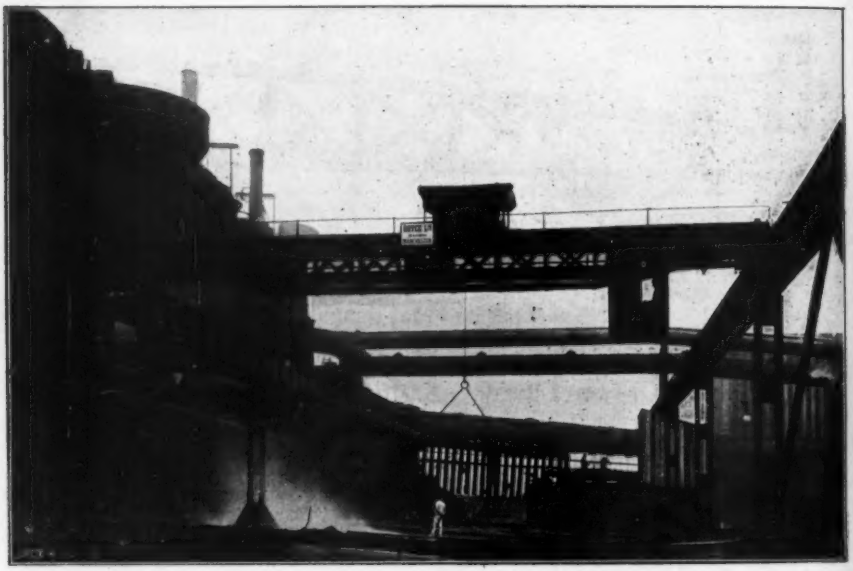

FIG. 2.—ROYCE ELECTRICALLY-DRIVEN OVERHEAD TRAVELLING CRANE AT MESSRS. JAMES DUNLOP & CO.'S FURNACES.

the control of varying mixtures with correspondingly varying slags.

Of course, where the mixture is continually changing, it is not remarkable to get a varying slag, but it is when the mixture remains unchanged or apparently unchanged for weeks, or even months, that we are often led to wonder at some of the results obtained quite suddenly and without warning.

Metallurgically, there is no lack of slag, a good or bad result is the case. But the unlettered smelter and the manager are equally cognisant of the fact, and in many cases each is as wise as the other, the only difference being that one speaks from general observation of colour and other physical properties and conditions, and the other from results of analyses.

When it is proved beyond doubt that in any two cases, all other conditions being

alike, and the atmospheric conditions varying, this one variable will be sufficient to revolutionise the working of a furnace and the nature of the slag obtained, it can be seen at once that it is not the final nature and constitution alone that we must study, but how to control our slag, and how to obtain or avoid, as the case may be.

To attempt to educate the average foundryman or foundry foreman by a display of chemical formula and equations, however simple and orderly to the chemist, is only to confuse his mind and frighten him away from the perusal of a subject which, touching as it does, his best interests, he would otherwise follow with pleasure.

A few elementary principles quoted on the subject of slags and what they really are cannot fail to be of interest to any reading or thinking foundryman or smelter. The latter, by-the-way, as being an "unskilled" workman is often left out of the equation when he is really one of the principal factors in the sum, and, properly encouraged and enlightened, could do wonders in promoting and keeping peace and concord in the foundry.

All metallurgical operations that involve the fusion of a metal, or an ore, or any mixture of such, and have for their object the recovery of one or more of the products of fusion, result in the formation of a slag or dross; generally, the product consists simply of two things, a metal and a slag.

Take the foundry as the most relevant example; the humblest observer in the foundry knows that the every-day stock that is charged into the furnace is quickly summed up into pig-iron, scrap, coke or coal, and limestone.

He observes also that everything that goes into the furnace is in the solid state, and all that comes out is in the fluid condition, or at least pasty or viscid. Of what does the slag consist, and how is it found? He has noticed that slag somewhat resembles glass; good slag is neither more nor less than an impure glass, for whilst the common or bottle glass consists of a "mixture" of silica (sand), calcium, and sodium (two metals), the ordinary or foundry slag is sand mixed with calcium and other metals in very much the same way.

It is a singular fact that the slag of any cupola melt is a true index of the quality of the iron accompanying it. The truer the composition and the more nearly the several silicates (always two or more) are satisfied in their chemical equivalents, the more fusible and tractable the resulting slag.

The slags consist of that portion of the fuel which is useless as a melting agent, namely, the ash, together with an unavoidable loss of good iron (which loss is important to the founder), dirt and sand carried in by the charge, and lastly, lime, or any other substance purposely added as a flux to help fuse and form a semi-liquid body of less specific gravity and much more complex though none the less definite and important composition than the iron itself; for a flux, roughly defined, is a substance that has the property of causing the earthy and sandy constituents of the iron and the coke to fuse or run at the temperature of the burning coke, and thus rendering them removable under furnace conditions.

Lime is invariably a constituent of foundry slags, whether added as limestone or not, but is usually added in that form or as fluorspar, for, be it noted, that whichever of the above two be added, it is only as lime (Cao) that they function with silica to form the silicate of lime or calcium in which form it exists in the slag; the raw bodies being calcined in their passage down the furnace and previous to their actual fusion. The relative properties and value of fluorspar as a flux are matter for much dissention and discussion in the foundry and metallurgical Press in this and other countries at the present time.

Slags, we have seen, are silicates or mixtures of silicates, capable of forming under good conditions, very definite and well-defined compositions. Very little has, however, been actually written about the nature and constitution of foundry slags. We have untold publications informing us that the blast-furnace slag is generally a double mono-silicate of lime and alumina of more or less definite composition, with varying quantities of this and that, but very little of similar detail with respect to the slag formation and control, as it concerns the founder, has been written. One eminent writer, at least, has seen fit to draw comparisons showing the similarity in the conditions existing in the cupola and the blast furnace, but, without a clear definition of just those details where the parallel ceases, so the comparison is more misleading than otherwise.

It is absurd, for instance, to consider the slags of a blast furnace and cupola slag as resembling each other, either in composition or conditions of formation; they can never be alike, and yet good

slagging is as important in the foundry as at the blast-furnace.

The great similarity in appearance of these slags is misleading, for it is the varying amount of free oxides in the slags that impart the colours, and as very small quantities only are required to give the tints the same colour may appear in any two slags of entirely different constitution.

A slag obtained at the blast furnace producing a foundry iron may contain upwards of 20 per cent. of alumina, extracted from the argillaceous matter of the ore, while the slag obtained at the cupola in remelting the same iron with a high ash coke will rarely contain half the amount, and the foundry melter is called upon to watch his slag jealously to see that it is kept of the proper order and consistency conducive to good iron and economic working, for iron is an expensive substitute for alumina.

Colour is one of the best means hitherto employed for telling the nature of a slag, and it is well known that all slags vary from white to black, and that generally the amount of oxide of iron, present as silicate, increases in that order.

A white, stony slag is said to indicate an excess of lime in the charge, but it is equally true that a deficiency of lime when conditions do not actually favour oxidation of iron in excess, will result in a whitish, stony slag, which may or may not be pumiceous in structure; these conditions may be abnormal, and when they occur it behoves the furnaceman to look to his lining, and he will invariably find that it is cut away in a shocking manner, either uniformly or locally—most probably the latter.

The normal slag, however, is coloured successively from grey to black, through the shades of blue, green, and brownish-red, according as the ferrous oxide increases, and it is generally found that a slag having a greenish tint is the best for furnace work.

Even when the slag is of a bottle-black colour, showing the iron in the slag to be high, conditions are often found to be favourable in spite of the loss, but when the cupola slag reaches this condition, it has nearly reached the limit of saturation by oxide of iron (combined to form the fusible silicate) for good working, even apart from economical considerations, and it goes without saying that many tons of iron are melted with the cupola working in this condition, and many tons of iron are dumped on to the slag heap in the form of slag which should have gone into the mould, if the slag had been more under control and the conditions of formation better understood. This condition of loss of iron is, of course, independent of loss of iron in the slag as metallic shot or beady iron, a condition of loss familiar to every observant founder, and which will often tot up to a considerable figure.

Metallic Shot.

Many observers of this phenomenon have given the losses by metallic iron as from 3 to 5 per cent. of the slag for a melt varying in weight from 20 to 50 tons, but as the shot would not have been carried out during the whole of the melt the loss as metallic iron on that portion of the slag which actually contained it would be much more than the percentage quoted above.

A peculiarity of this shot iron is that it is rarely ever visible on the surface of the slag, but is generally embedded well into the mass of slag, and is clean and white and often intensely hard. When shot is noticed on the surface of the slag, it is often due to a stream of molten metal escaping with the slag and splashing onto it in the slag pit.

Samples of iron recovered were found embedded as shot in long fingers or stalactites of slag, of about half-inch thick, the finger of slag being of a black, stony external appearance, rich in oxide of iron, with an inner ring of manganiferous, green slag, containing the shot of iron as a nucleus, presenting the appearance of a metallic solid eutectic in a matrix of parti-coloured slag; the shots were perfectly clean and bright, and in the sample examined (not representative) would be more than 5 per cent., calculated on the whole of the slag produced by the melt.

There can only be one explanation for the inclusion of metallic iron in slag in this way, and that is, a condition of coldness at, and below, the tuyere level.

It is well known, of course, that iron when melting trickles from the vicinity of the melting zone, or the "zone fusion," past the tuyeres in the form of isolated drops of *molten shot*, and only in the case of very rapid melting does it form a stream; this condition of melting is easily observable on looking through the observation glass of the tuyere. The drop of metal passing through the blast belt under cold conditions and into a layer of slag already

cooled by the same conditions is frozen and becomes embedded in the slag and never finds its way into the bath of molten iron, but is carried away with the slag, through which, under ordinary conditions, it would have percolated by reason of its superior fluidity and specific gravity.

This condition of things may be caused either by a cutting blast, insufficient coke or an inferior coke, all of which would result in a reduction of temperature in the vicinity of the tuyeres, and also oxidation of the iron, which is known to accompany shot formation in the slag. A continuation of these conditions of burning, viz., where an insufficiency of carbon leads to the burning of the iron and an abnormal formation of ferrous silicate, turns the slag black and scouring, and the iron white and hard, robbing the iron of silicon for its silicate, and in turn robs the iron again of its carbon, with the formation of carbon dioxide, and producing that very abnormal slag condition known as "foaming slag," experienced by almost every founder at some time or other.

So long as this peculiar slag can be successfully foamed from the slag notch all is well, but this is not possible for very long when the conditions are fairly under way, and once the slag is allowed to rise beyond the blast it may be carried by the blast as far as the charging door, and on to the platform or charging stage. This is what happens when the cupola is allowed to burn iron beyond the limit mentioned above, and is a state of things happily not met with often, but is a truly abnormal one, and as striking as it is regrettable.

Several instances have been published of this most phenomenal occurrence, but there can be little doubt that this enormous increase in the bulk (not quantity) of slag is brought about by the oxidising conditions quoted above, culminating in the copious evolution of carbonic-acid gas, puffing up the spongy slag to beyond the lower blast belt (where double rows of tuyeres are used), where the blast begins to assist as a foaming agent.

The generally accepted remedy for foamy slag is to reduce the blast, or to stop it altogether for a time, but when this is done carelessly it is possible to fill the tuyeres and half the blast-box with slag, even with the slag notch full open.

These reflections and sidelights show the necessity for every person responsible for melting becoming keenly alive to the importance of the slag question, and of attaining at least, some intelligent idea of what slag really is and the conditions affecting its constitution and change; and, again, on the part of foremen and managers, of the institution of some system of analysis of stock and mixtures, also slags; the system may be simple yet effective.

Very often a rapid and approximate chemical test of "first iron" and slag for main or chief constituents, made, as they are, at the commencement of the run, will give sufficient time and opportunity—necessity demanding—for effecting changes in the cupola charge, which will ensure comfort and safety for the rest of a long day's work.

The analyses need not be complete either in the case of the metal or the slag, for as a rule, if one or at most two, of the chief constituents of either are "normal" they answer for the rest. Take the iron, for instance; the fact, by this time, is generally admitted that if the silicon content in the cupola product is normal, all things, as a rule, run smoothly for general purposes, for even in the case of hard, white iron, required for special purposes, the silicon will generally speak for; at least, the carbon, since the saturation point of an iron for carbon will increase or decrease as the silicon rises or falls, low silicon generally being accompanied by low carbon. Moreover, experience shows that any one cupola working under identical conditions from day to day will, with uniform working, vary little in regard to the quantity of metalloids lost or gained, and any sudden change in the working of the furnace can at once be detected by a quick and ready chemical test, and any loss in the iron, due to the removal of a metalloid which is not capable of volatilisation, will invariably be found to result in a corresponding increase of that element in the slag.

Many careful founders follow out a system of mechanical tests which, of course, have their value, and it would be very hard to convince them of the value of the chemical test when melting, or its advantage over their own rough observations, which in time must entirely disappear, just as grading and selling of pig-iron by fracture will ultimately give place entirely to analyses.

It is quite true that some of these mechanical tests are so effective that they may be permanently adopted as necessary adjuncts to analyses; for instance, the car-wheel founder, with his "chill" test bars, and the malleable

ironfounder, with his shrinkage "sulphur" bars, obtains a very good and rapid guide for working within rough limits, but the ultimate analysis of the furnace product can alone tell "the tale of the melt."

Chemical analysis of a slag obtained with the best results will show the composition of the slag most suitable for the conditions obtaining at the plant, and that slag is adopted as a standard which may or may not be the true monobasic slag, which is found to be the general product of the foundry cupola, and has a composition approximating to the following:—

	Per cent.
Lime	35
Ferrous oxide	5
Alumina	10
Silica	49

These are the main constituents, and, of course, do not exist in the form named above, but the first three are combined with the silica as silicates.

The alumina seldom rises above 11 or 12 per cent., in this respect differing very materially from the blast-furnace slags produced by smelting clayey ores. A foundry iron may give a slag containing 22 per cent. of alumina when smelted from the ore, and on remelting the same iron at the cupola the slag may contain only 10 per cent. of that body, which amount is quite independent of the iron, being derived chiefly from the coke ash.

The sum total of the first three constituents of the above table will be found to equal approximately the silica above, *i.e.*, the silica and the bases are about equal, hence the name "monosilicate." The manganese oxide may vary from 1 per cent. to 2½ per cent., and sulphur, as sulphides of calcium and manganese, from 0.1 to 0.3 per cent.; the above data will only apply when a flux is used in remelting.

Besides limestone and fluorspar, we often find oyster shells and other shells prescribed as fluxes. Chemically, of course, these materials resemble limestone, but the fact that they are apt to contain phosphorus is often overlooked, and where purity of product with regard to this element is desired, as in the case of cupola melting mixtures for steel-making, shells are best left alone, or, at least, they should be well washed before using; of course, where phosphoric foundry mixtures are being melted, no care need be taken.

Fluorspar.—Reverting to fluorspar as a flux, some founders applaud and regard it as a boon and a blessing, while others are equally vehement in condemnation.

Now, though some of the best friends of fluorspar as a flux are, hitherto, those who have got a lot of it to sell, there is much to be said for this substance as a slagging agent under some conditions.

One special claim for fluorspar (calcium fluoride) is that its use as a flux is attended by a reduction of sulphur in the iron. Disregarding any claim to the opposite, it is interesting to consider how this reduction of sulphur in the iron is possible, and in what other way calcium fluoride is superior as a flux to limestone (calcium carbonate). It is well known that when Mr. Saniter first introduced his process of removing sulphur in the basic open-hearth steel process, by means of calcium fluoride, many operators objected to and discarded the process on the grounds that the fluorspar which was used contained more sulphur than it should contain, in many cases a higher percentage than it was required to remove. This, undoubtedly, in many cases was true, but this only showed the necessity for a pure grade of fluorspar.

Some time ago, while controlling the mixtures for a furnace producing a very pure brand of iron, the writer was called upon to investigate the sudden rise of sulphur content in the iron; it was eventually traced to an impure brand of fluorspar being used as a flux, *i.e.*, one containing mineral sulphides, disseminated through its mass.

On this and other proof it may be positively stated that it is easier to obtain a pure limestone than a pure fluorspar.

Granted pure spar, why should it possess the great advantage claimed for it?

Glancing at the chemical composition of the two fluxes, we see that while limestone is really lime combined with a gas well known as carbonic acid, or carbon dioxide, fluorspar is calcium (the base of lime), combined with fluorine, a gas much more chemically active than carbon dioxide, the latter gas, as is well known, being chemically very inert.

Where large quantities of limestone are used for the purpose of fluxing, it has even been considered worthy of discussion and trial as to whether it is not more economical to calcine the limestone separately and use the lime direct in the furnace, as the decomposition of limestone by heat, according to the equation $CaCo_3 = Cao + Co_2$, is a dead loss in the heat economy of the furnace when considered thermally, with the re-

quisite amount of fuel to effect the reaction; the gas Co_2 simply passing out with the other gases at the top of the furnace.

In fluxing, it is generally considered that this change, viz., the liberation of the gas Co_2 and the formation of lime, occurs at a temperature below and at a point above that where the lime becomes active as a fluxing agent, and it is here where the principal difference of the two used in the cupola, the gaseous part of the compound fluorine, passes off, not alone, but in combination with silicon as gaseous silicon fluoride.

A study of the thermo-chemical properties of calcium fluoride may show that its temperature of decomposition is much higher than that of limestone; if this were not so, then free fluorine must pass off in the gases, for reasons seen in the sequence; this being so, we see the possibility of the active lime being carried further down the charge and becoming released uncontaminated in that zone where it is most desirable. Moreover, the form in which it is released is not that of lime as in the case of limestone, but as calcium, according to the following three equations:—

(1). $Ca\ F_2 = Ca + F_2$
(2). $^2Ca + O_2 = 2CaO$
(3). $Si + 4F = Si\ F_4$

Supposing calcium fluoride to be readily decomposable, and presenting its very active fluorine atom for combination at the low temperature of lime formation, it is known that fluorine does not combine directly with silica, but, as shown by No. 3 formula above, combines with silicon, which provides the necessity for the decomposition of the silica or, as a substitute, the robbing of the iron of silicon which could not occur short of fusion.

Now, it is a fact well established amongst metallurgists who have made special study of high temperature reactions, that it is only at very high temperatures that silica (SiO_2) is decomposed at all, and then only when some friendly element is at hand to accommodate the oxygen atom, as for example, the absorption of silicon by iron in the hottest part of the blast furnace.

It will be seen, therefore, that there is sufficient difference in the chemical conditions of the two cases to warrant the expectation of different results from their use.

One result that positively accrues from the use of fluorspar as a flux is an increase in the fluidity of the slag, either when used alone or in admixture with limestone, and as the product is the same, viz., lime and silicate of lime, the ultimate difference can only be a physical one, and shows that the cycle of changes taking place in the peculiar conditions noted above must be such as to produce a strongly exo-thermic result, with an increase of temperature permitting of a clearer and readier separation of slag from metal, and a better opportunity for the calcium sulphide to liquate into the slag, with corresponding reduction of sulphur in the iron; in fact, if silicon fluoride is actually evolved at the furnace mouth, a very high temperature at the zone of actual fusion is essential.

Again, it must be remembered that weight for weight fluorspar (pure) contains about 10 per cent. more of the lime-producing calcium than does limestone, so that less spar is needed for a given amount of fluxing.

It is well argued too, that while 44 per cent. of the limestone used is volatilised as carbon dioxide and is useless as a flux, besides carrying off heat, the whole of the calcium fluoride is utilised, as not only does the base (calcium) form lime, but the fluorine, it is claimed, passes off entirely as silicon fluoride, leaving less silicon to be fluxed by the lime.

Calculated in view of the last-mentioned fact, fluorspar has about twice the fluxing power of limestone, and the only reason why fluorspar is better used in admixture with limestone is, that mixing the two together and giving a larger quantity of flux causes a better distribution of the flux over the cross section of the furnace and the charge in general. This uniformity or spreading of the flux is a point not to be overlooked, and the superiority of limestone over fluorspar with regard to this property doubtless accounts for many of the statements as to the unsatisfactory nature of fluorspar as a flux. Undoubtedly it acts better in admixture and is more effectively used when the furnace has got well heated up than when used for the first two or three charges.

Quantity of Flux.

So far as quantity of flux is concerned, this, of course, is very important, and many elaborate methods may be enumerated in which the quantity of fluxable material in the charge and the amount of free flux operating is shown in an imposing array of chemical and algebraic formula, or the graphic determination of the quantity of flux required is shown to be possible, but all these methods require that the exact amount of silica and other

slag-forming elements entering into the charge be known to the operator, and, so far as general foundry practice is concerned, this is just what one founder in a hundred does not exactly know. And so one finds such differences of opinion existing as to what quantity should be used or what method of figuring adopted.

The application of a good graphic method to the chemical analyses of a coke and limestone will show how far the coke ash is self-fluxing, and how much of the calcareous properties of the limestone are required to flux its own impurities, but the unknown and practically undeterminable quantity of the sand and dirt carried in on and by the charge, upsets all these fine calculations, and it is found impossible to treat a cupola charge with the same precision as the charge of an assay pot in the laboratory.

The general practice is to figure the limestone either on the coke or on the metallic charge.

The general quantity used by metallurgists of up-to-date methods is about 24 to 26 per cent. of the coke charged; taking the mean of this, and where the melting ratio is about 6:1, this will give about 4 per cent. limestone figured on the pig-iron. Much less is often used, but these are convenient figures for all concerned in the figuring of cupola mixtures, and are reliable for all general purposes.

As an extreme measure the writer has tested the efficiency of a maximum of 35 per cent. on the coke, and 5.5 per cent. on the pig and scrap; this should never be exceeded and, in fact, seldom reached.

White marble is the best kind of carbonate to use, though as whiteness as a rule is no actual guarantee of purity, little discrimination is necessary.

The advantage of marble over the softer limestones and the shelly carbonates is purely a physical one, as the extremely friable varieties are apt to disintegrate early on in the descent and to be blown back into the throat and stack of the furnace.

Pure limestone contains 56 per cent. of lime and 44 per cent. of carbon dioxide gas, as shown by the following molecular formula which may be of interest to the foundry student studying fluxes, in which the molecular weight of limestone is appropriately 100, of which 56 is lime:—

Lime	×	carbon-di-oxide	=	limestone
Cao	×	Co_2	=	$Ca\ Co_2$
40×16		$12\times(16\times2)$		
56	×	44	=	100
100				

Limestone for cupola use should not contain less than 50 per cent. of lime, and as much over as possible. Sulphur should be *nil* to 1.5 per cent. (the less the better).

A limestone of the carboniferous variety, containing 97 per cent. of carbonate, or 54.3 per cent. of lime, is an excellent one, though rather softer than the argillaceous, or lias variety, which latter generally contains much more sulphur and, of course, always more silica than the purer variety first mentioned.

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SCIENCE VERSUS RULE OF THUMB.

By M. I. P.

In no other trade in the mechanical world is there such opportunity for the accusation of the employment of rule-of-thumb methods as there is in the foundry trade. Moulders are often accused of employing empirical methods in the pursuance of their daily work, and not without cause. Take any other trade in consideration, and it will be found that its progress in reaching its modern conditions has been a gradual state of evolution of methods and material consequent on science and research, and that its present conditions differ very much, and, in some cases, entirely, from those which have obtained at earlier periods. The general advance has been along the line of the substitution of machinery for hand labour, and the substitution of other methods of handicraft and materials of construction, resulting from scientific research and experimental work.

It has been asserted that foundrymen have been slow to move with the times, and that their methods are less scientific, less mechanical, and more antiquated than those employed by other trades. We cannot deny that in many cases the assertion is somewhat justified, but there are different conditions existing in, and surrounding, the foundry trade compared with other trades.

Moulding and casting in metal is one of the most ancient arts practised in the history of man, and this fact, at first sight, would only increase the wonder that old-fashioned methods should still obtain.

There is evidence that castings were produced in ancient times that compared very favourably with, and, in some respects, even excelled, those produced by modern workmanship. A visit to some

of the ruined temples in the East, especially Egypt and some parts of India, would be sufficient to settle that point. It is inconceivable that the argument of "lost art" which applies so well in the case of some achievements of the ancients will apply in the case of those magnificent, massive castings produced in bronze, and which still exist in some ancient ruins.

Practical knowledge and common-sense can only conceive the absolutely necessary and crude materials to the hand of the ancient worker, namely, sand, fuel, and metal; the present-day moulder requires little more for the production of his best results, and as all these were as easily obtainable in the past as at the present time, it is not to be wondered at that what did for the ancients will do very largely for the modern worker. Others have advanced by sheer necessity, which is the finest spur to progress. The moulder, however, requires nothing for the elementary pursuance of his craft than the very humble outfit mentioned. It is possible, then, that the moulder is not so far behind as he may seem, or, if he is, that the fault is not his own. One fact will be generally admitted, both by "rankers" and those in command, that since his outfit is so meagre, there is no other trade extant where the "personal equation" enters so much as in the moulder's craft.

The writer's experience is that there are "born" moulders and others, and some of the best workmen seen by him as practical exponents of the trade have been untutored and illiterate men. Not only so, but it is here asserted that some of the very best castings produced in all branches of the foundry trade are at present being produced by the class of workmen who have not the least pretension to education or superior intellect. To what, then, is this due? Past writers on the subject have described that quality in the moulder of being able to do the right thing at the right moment, without being able, when questioned, to say exactly why he did it, by such names as "sagacity," "instinct," etc. Whatever it may be, it is a most necessary and valuable quality, and by reason of the peculiar circumstances surrounding the trade, it must always exist as a foundation of the moulder's skill, however much it may be supplemented by mechanical improvements and science. The reason for the existence of this skill among illiterate men of any trade is, of course, that of natural aptitude, and the possession by some men of a superior capacity for concentration and careful attention to details.

The neglect of perhaps only a single detail in a week's work will lose a large and costly casting, and it is often a fact that an intemperate man will get good castings and keep his place because he is a good "rule-of-thumb" man and is careful in his work.

It does not follow, however, that this class of man, given a new and difficult job embodying new principles, will be more successful than the technical man. It is often found that the most successful moulder is either one that has had a "lifetime" in a special work, or one who has travelled to such an extent that he has more rules under his thumb than his neighbour.

It is stated that America is ahead of us in moulding methods, and behind us in quality of materials; this may or may not be so, but the author has never yet met an English moulder who has "done" the States, but has been wonderfully improved in his ideas, or, at least, been more resourceful and prolific in ideas. This, of course, may be due, not actually to American influence, but to travel generally, the advantage of which is obvious.

Proof of the moderately good work obtainable by "rule-of-thumb" methods could be found among those in the trade whose lot it has been to run foundries with Oriental or African labour. The chief characteristics of the Oriental workman are (1) his tendency to metaphorically fall into a rut, or get accustomed to a rule, from which it is hard to get him out; (2) his lack of initiative, which, of course, necessitates incessant supervision, and (3) his capacity to imitate, or produce from a sample, a perfect replica in any workable metal or wood, with tools of the very simplest form imaginable. His methods and progress are necessarily slow, and his results not comparable with those of European workmanship, but those who have watched the slow and sure means by which the Indian or Egyptian workman attains his end, have, to some extent at least, ceased to wonder how the great works of engineering skill of ancient times were accomplished.

The Oriental capacity for copying in wood is a valuable one in those workmen employed as pattern-makers, where the absence of drawings and other circumstances render it necessary to work to a sample or model.

The Indian carpenter or pattern-maker will sit for hours at a stretch upon his bench and upon his haunches, and, scorning to use a vice, will grip his pattern or unfinished job with his feet and toes and work upon it with his hands, thus having an advantage of two hands over his European neighbour. An exact counterpart will be forthcoming in due time, and faults of shape or design in the model will be faithfully reproduced in the pattern.

The foregoing remarks on rule-of-thumb methods, as showing their applicability, are not intended in any way as a justification of their employment; on the contrary, they are to be deplored, and must eventually disappear as modern necessity demands.

Operations performed in the scientific laboratory are productive of anticipated or foreseen results. By a knowledge of the fundamental laws governing the phenomena, the operator can control his result, and can invariably explain minutely the cause of failure, should it occur. Can a moulder do this? Too often he cannot, because in many cases the circumstances or causes underlying the failure are those over which he has no control, and, in many cases, knows nothing about.

The finest "rule-of-thumb" workers are daily confronted by an absolute failure of their pet rules and best efforts to produce a good result. To the best of their knowledge no change has been introduced, yet castings fail. It is here where the foundry fails daily to satisfactorily answer the criticism levelled at it, and discloses its lack of technical ability amongst its workers.

Science, pure and applied, but especially technical science, must in the end affect this as much as any other trade. The foundryman of the future must be as technically intelligent and as well advanced in the principles underlying the phenomena and results of his work as the average mechanic. The advantages of geometrical knowledge to the moulder are obvious; innumerable instances occur where a moulder with plain geometrical instincts may quickly and accurately get a job in hand, while the average moulder loses time by sending for the pattern-maker to come and set out his work and fix his strickles. A moulder with a knowledge of projection as applied to three-view drawings or rough sketches, will grasp far quicker the aspect and possibilities of his job than one who regards his pattern as an object only, and not as the embodiment and result of design and draftsmanship.

So far as the actual preparation of moulds is concerned, hand-moulding may be said to be divisible into four operations, viz., setting, ramming, drawing, and finishing.

In machine-moulding, "setting" and "drawing" of patterns are performed mechanically, that is, in machines of the "stripping-plate" type, while in the case of power machines the ramming is also done mechanically. Moreover, in properly designed and operated machines the amount of "finishing" is reduced to a minimum. But for the finishing necessary for machine-made moulds and for all of that necessary for hand-made moulds, good moulders will always be required, as finishing and repairing of broken moulds can never be done by machinery, any more than the subsequent operations of hauling, transmitting, core-setting, closing, casting, shaking out, etc., can be done by the turn of a lever. Whatever moulding machinery may do for the increasing of output, saving in time and labour, and cost of production generally, it can never abolish the necessity for good hand-finishers, especially in the case of loam work.

It is easy to conceive how an intimate acquaintance with freehand and geometrical drawing must assist the moulder in the matching of the sound and broken parts of a mould representing a pattern of symmetrical shape or form. This training of the eye to defects in the shape of moulds would also enable a foreman to quickly detect the faults in the work of the men. The importance of drawing, mechanical and freehand, should certainly be urged upon the foundry student as at least one branch of science in which a means of improvement can be found.

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Mr. H. Nance, of 4, Church Street, Cardiff, has been appointed the Welsh and West of England agent for Wm. Wadsworth & Sons, Bolton; Nalder Bros. & Thompson, Limited, London; Newtons, Limited, Taunton; and Ward & Goldstone, Manchester.

The directors of Richardsons, Westgarth & Company, Limited, of West Hartlepool, have expressed the opinion that the proposed amalgamation of certain marine engineering businesses on the North-East Coast would be greatly to the advantage of the industry.

CAST STEEL ROLLS.*

WHERE great accuracy is desired in rolled goods, such as rails, fishplates, etc., steel rolls are inferior to iron, owing to their greater expansion when heated, and also because the hardening and tempering of the rolls produces small cracks, etc., which cause unevenness in the rolled articles. In other cases, the longer life of the steel rolls makes them more economical than iron.

The moulds are prepared with templets and counter templets, the latter being used to ensure accuracy in the fitting of the two halves of the mould. They are preferably faced with sheet iron (Fig. 1), and an allowance of 1.2 to 1.4 per cent. should be made for the shrinkage of the mould. Octagonal boxes, divided longitudinally, are preferred, and these are built up in sections to suit the different lengths of rolls. The best moulding material is Dinas stone, from the lining of open-hearth furnaces, this being ground and mixed with clay. If quartz be used, it should be calcined, to prevent it swelling in the mould, and the same applies to magnesite. To employ once-used moulding sand over again, it should be faced with a thin layer of fresh material.

To obtain clean, smooth surfaces on the finished rolls, the castings should be made correspondingly large, the margin on the lower shank being about ½ in., but larger (4 to 8 in.) at the upper end, in order to allow the molten metal to flow readily and prevent the formation of cavities, which would prove a source of weakness. The cogs at the lower end may be cast with the rolls, but those at the top should be cast solid and milled out afterwards. The tapering form of head, shown in Fig. 2, is preferable to a shoulder, as being less liable to cool and obstruct the flow of metal.

The cooling of the steel, in order to reduce the head and save metal, can be effected in various ways (iron rods, cages, etc.), a useful form being the ring, R, shown in Fig. 3, which lessens the formation of cavities, and drives them further into the centre of the roll. The pouring is effected from below, the gates (Fig. 2) being 2-3 in. in diameter. The arrangement of several superimposed gates lessens the tendency of the moulding sand to burn on to the casting. An important point is that the steel should not be too hot at the time of pouring, or it is more likely to burn the sand, and cause large cavities and cracks. Shrinkage is facilitated by loosening the top section of the moulding box about 1½ to 2 hours after pouring, the others in 6 to 8 hours. The steel should have a hardness of No. 2-3 on the Styrian scale. The chemical composition is less important, except that the carbon content should be 0.7 to 1 per cent., and the silicon about 0.1 per cent., the other ingredients fluctuating between the limits customary in practice. To equalise the internal strains the castings should be annealed.

FIG. 1.

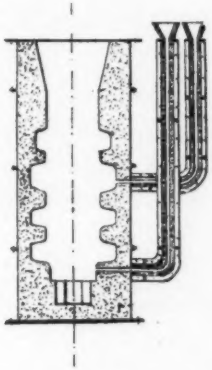

FIG. 2.

FIG. 3.

CAST STEEL ROLLS.

* "Giessarei Zeitung."

THE WILKINSON PATTERN PLATE.

It is often desirable to reduce the cost of putting patterns on a plate to the lowest possible point, to allow orders for small castings to be executed by machine or by plate moulding when only a small number is required. The Wilkinson pattern plate, which is illustrated herewith, has been designed to meet such cases. The total cost of making metal patterns by this method is that of making one mould, cutting off the runner, brushing up and varnishing the pattern plate. The pattern metal can be re-melted when the pattern is obsolete. The apparatus can be made in any convenient size to suit existing boxes, and lugs may be furnished undrilled to be drilled by users to suit their boxes.

The apparatus consists of pattern plate, and two casting plates (Fig. 1). The central bar of the pattern plate is removable so that it may be fitted either with one pattern the full size of the box, with a number of patterns the full width of the box (Fig. 2), or with patterns half the width of the box (Fig. 3).

Only a short time is required to prepare the plate, and no special skill is required. In ordinary plate moulding, with a number of patterns on a plate, if one pattern becomes damaged it cannot be repaired and the whole plate is spoiled; but by the method now being described any single pattern can be removed and replaced at a small cost.

To prepare a pattern plate a mould is made from the original pattern in the ordinary way, care being taken to make the joint level. The casting frame is then put into position on the bottom box, and the sliding bar adjusted to make the plate the proper width to take the pattern. The gate is then cut in the top box to run into the slot in the casting frame; the box is then closed and cast with pattern metal, and providing this has been poured at the proper temperature the plate will come out bright and clean, and only needs the gate sawn off, brushing up, and varnishing. The pattern frame is then filled with these plates, and used in the ordinary way. When the required number of castings have been obtained from one plate it is withdrawn, and another substituted in its place.

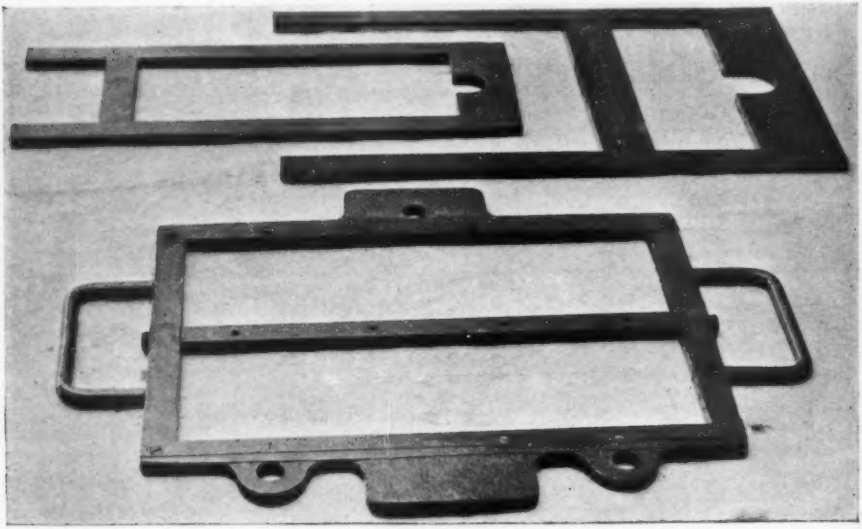

Fig. 1.—The Pattern Plate and Casting Plates.

In regard to the pattern metal, various alloys are suitable for the purpose, amongst the most used being the following:—

Lead, 90; antimony, 10—a metal having small shrinkage.

Zinc, 66; tin, 34—a harder metal and with small shrinkage.

Lead, 50; tin, 50—a metal soft and liable to damage in ramming, but suitable for use in a moulding press.

Lead, 55; antimony, 30; tin, 15, or type-founders' metal, this alloy giving good results.

The makers of the apparatus described are Messrs. J. W. Jackman & Company, Limited, Caxton House, London, S.W.

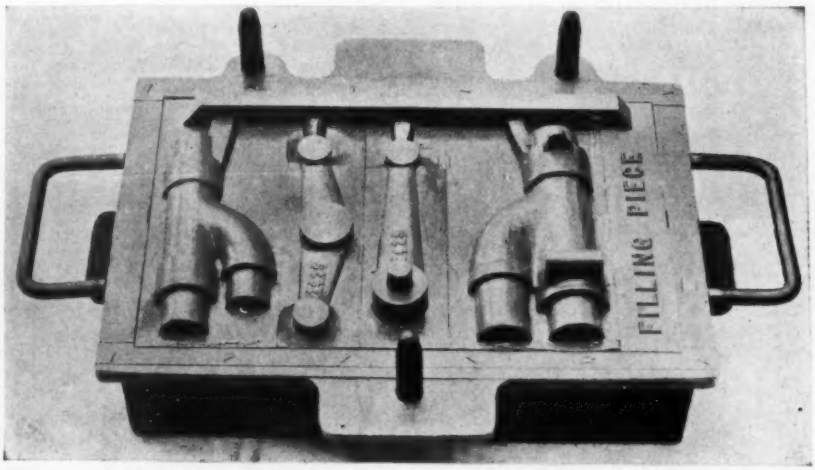

FIG. 2.—THE PATTERN PLATE WITH SET OF FULL WIDTH PATTERNS.

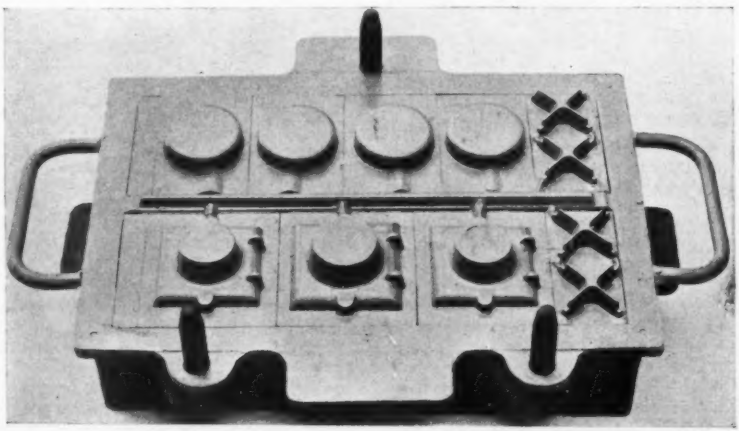

FIG. 3.—THE PATTERN PLATE WITH CENTRAL BAR AND SET OF PATTERNS.

THE JORN SAND BLAST APPARATUS.

After several years of experimenting, A. Jorn, Jun., Waukegan, Ill., has developed and is now manufacturing the sand blast apparatus shown in the accompanying illustrations. Since the machine itself collects, screens and returns the sand for repeated use (except that which is lost as dust through the exhaust pipe), frequent stops for recharging are obviated. A greater range of work and more accurate work it is claimed can be done with this apparatus than with a hose sand blast. The standard 18-in. size will sand blast an area of from 150 to 180 square feet an hour.

The sand is supplied from a hopper, near the delivery end of which is a grooved roller which rotates while the apparatus is in use and drops charges of sand in the path of an air blast delivered into the nozzle in a direction to carry the sand through the mouth of the nozzle and into contact with the articles to be cleaned. The nozzle provides means whereby the sand blast may be limited to a circumscribed area. After the sand has been projected upon the work, it is conveyed to the hopper to be used over again repeatedly.

The accompanying Figs. 1 and 2 show exterior views of the apparatus, and Fig. 3 shows it with the enclosing sides removed, and also gives a detail section of the blast nozzle and sand-feeding device. As may be seen from Fig. 3, there is a main frame supporting another frame at the ends of which are journalled transverse shafts carrying rollers. These rollers carry endless belts upon which the articles to be treated are placed. The sides which enclose the frame are protected by a rubber lining, and the belts are also of rubber, as is usual in sand blast apparatus.

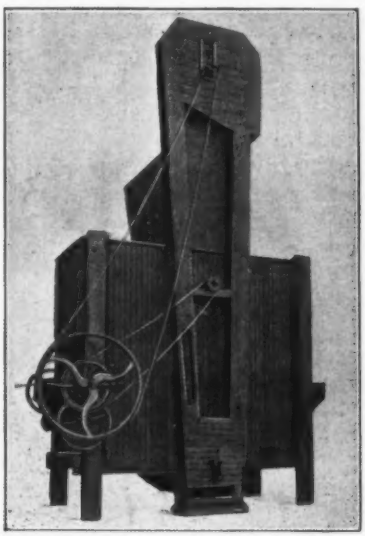

Fig. 1.

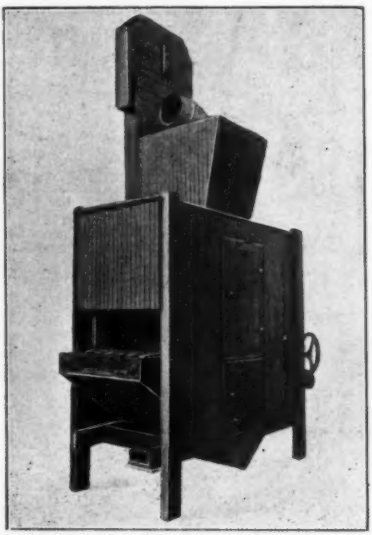

Fig. 2.

The Jorn Sand Blast Apparatus.

Below the belt frame is a receptacle having a bottom inclined toward the centre, where it discharges into a trough containing a screw conveyor leading to the bottom of a bucket elevator. The latter delivers the sand through a spout into a hopper fastened on the platform carried by the frame. Below the platform and the hopper is a sheet metal receptacle, with an opening in the top communicating with a chamber enclosed by vertical parallel walls. The lower ends of the walls approach each other to form a contracted throat, and within the cham-

ber above this throat is a drum with a circumferential series of horizontal grooves. The drum is mounted upon a shaft having bearings in the end walls of the casing, and at one end this shaft is driven by a chain from the main driving shaft. A deflector above and a lip bearing against the side of the drum, direct and limit the flow of sand into the throat, except as allowed by the rotation of the drum. Assuming the rotation to be continuous, each groove will carry a charge of sand from one section of the compartment to the other, and a continuous series of charges will gravitate through the throat.

Between the outer walls of the casing

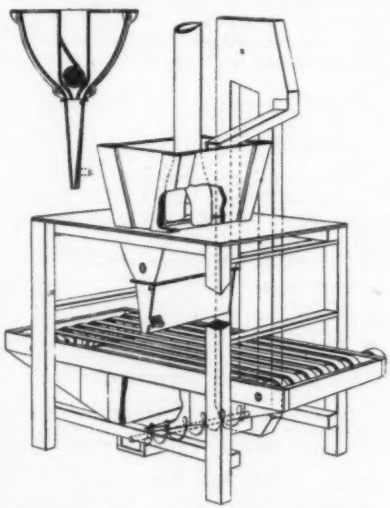

FIG. 3.—SHOWING THE JORN APPARATUS WITH THE SIDES REMOVED, AND A DETAIL SECTION OF THE NOZZLE.

are chambers on each side of the sand compartment. The outer walls also approach each other toward their lower ends, thus forming other throats on each side of the sand chamber throat. An opening through the top of each chamber is connected with a bifurcated pipe, which supplies air under pressure. Below the throats is a nozzle, the walls of which approach each other toward the discharge end. One wall is hinged at its upper end, so that the area of the discharge may be regulated.

When the hopper is charged with sand and the conveyor, the elevator and the drum are in properly-timed movement and air is fed under pressure through the conduit, the articles to be cleaned are placed upon the belts and are slowly conveyed beneath the open end of the nozzle. The streams of air entering the outer chamber pass forcibly through the throats and into the nozzle, taking up the sand, projecting it against the work as it passes slowly under the lower end of the nozzle while resting upon the belts. After the sand has performed its work it falls through the spaces between the belts, and finally into the trough where it is carried by the conveyor into the lower end of the elevator, to be carried to the top of the latter and delivered again into the hopper through the spout.

The size of the stream passing out through the nozzle and, in a measure, the speed of the stream of sand-laden air may be regulated by adjusting the nozzle opening, and this may be done while the air pressure in the pipe is being maintained practically constant. The same source of power drives the various parts, including the blower by means of which air pressure is maintained, and consequently it is advantageous to regulate the force of projection of the stream of sand laden air by constricting or expanding the nozzle opening rather than changing the air pressure by varying the speed of the blower. By adjusting one side of the nozzle so as to vary the relative inclination of the nozzle sides, there is practically no abrasive action of the sand upon the walls.

While the machine is especially adapted for cleaning castings, it may be used for sand blasting glass either in plain or in ornamental designs, or may be used for numerous other purposes for which sand blasting apparatus is adapted.—"Iron Age."

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THE MIRRLEES WATSON COMPANY, LIMITED, have removed their London office from 139 to 225, Gresham House, Old Broad Street, E.C.

MR. H. PLUMPTON has purchased the plant and works of the late firm of Herbert Plumpton, Limited, Excelsior Tool Works, Liverpool Road, Warrington.

MR. C. WILSON, who has severed his connection with the Chatteris Engineering Works Company, has removed to 225, Gresham House, Old Broad Street, London, E.C.

MESSRS. MORRISON & COMPANY, of 5, Budge Row, London, E.C., and Valparaiso, have been appointed contractors for engineering stores, etc., to the Chilian Navy for a period of five years.

GRADING FERRO-ALLOYS.*

Owing to the fact that many of the ferro-alloys have only been in use for a comparatively short time, the fixed standards have not in many cases been adopted. One company designates its material by showing the number of units of carbon by "X" and the kind of alloy by its letter symbol; thus a ferro-chrome containing 9.70 carbon, it would designate 9 x C.

Ferro-Aluminium is sold containing 10 per cent. aluminium. Higher percentages are also used in iron and steel, No. 1 being guaranteed over 99 per cent. pure aluminium. No. 2 is guaranteed over 90 per cent. aluminium, with no injurious impurities for alloying with iron and steel. It is sold by the pound.

S. A. M. Alloy.—This is an alloy of silicon, aluminium, manganese, and iron. One partial analysis showed:—

Silicon	8.01
Aluminium	6.80
Manganese	8.39
Phosphorus	0.075

Ferro-Chrome usually runs 60 per cent. to 68 per cent. chromium. It is graded per unit of chromium and per unit of carbon, the price increasing with the chromium and decreasing with the increase in carbon, these elements being guaranteed. If low in carbon, it is sometimes called "mild." A typical analysis, chromium and carbon only guaranteed, is as follows:—

	Mild.	Ordinary.
Chromium	64.80	66.00
Iron	33.43	21.91
Carbon	1.21	9.20
Silicon	0.29	1.40
Phosphorus	0.027	0.07
Sulphur	0.02	0.22
Manganese	0.09	0.20
Copper	0.12	—
Aluminium	—	—

It is sold per ton, 2,240 lbs.

Ferro-Manganese contains over 40 per cent. manganese.

Standard Ferro-Manganese is only guaranteed to average 80 per cent. or over manganese. The English runs lower in phosphorus than that from the Continent. A typical analysis, manganese only guaranteed, is as follows:—

	English.
Manganese	80.50
Iron by difference	11.50
Silicon	1.65
Phosphorus	0.23
Carbon	6.78
Sulphur	—

It is sold per ton, 2,240 lbs.

Ferro-Molybdenum is sold per pound of pure molybdenum contained, regardless of the percentage of other material. Thus, if a pound of 80 per cent. ferro-molybdenum is purchased, 1¼ lbs. of the alloy will be received. A typical analysis, the units of molybdenum only guaranteed, is as follows:—

Molybdenum	79.15
Iron	17.55
Carbon	3.24
Phosphorus	0.028
Sulphur	0.021

Nickel.—As ordinarily used in steel this is guaranteed over 99 per cent. nickel, and is sold by the pound.

Ferro-Nickel is also supplied with 25, 35, 50, or 75 per cent. of nickel as specified. The balance of analysis outside of the nickel and iron runs about:—

Carbon	0.85
Silicon	0.25
Sulphur	0.015
Phosphorus	0.025

Ferro-Phosphorus contains over 10 per cent. phosphorus. The foreign is guaranteed 22 to 24 per cent. phosphorus. A typical analysis of foreign, the phosphorus alone being guaranteed, is as follows:—

Phosphorus	21.40
Iron	75.03
Manganese	0.70
Silicon	1.63
Carbon	1.17

The American is guaranteed:—

Phosphorus	18 to 22 per cent.
Sulphur	under 0.05
Manganese	under 6.50

It is sold per ton, 2,240 lbs.

Phospho-Manganese.—A typical analysis is:—

Manganese	65.00
Phosphorus	25.00
Iron	7.00
Carbon	2.00
Silicon	1.00

Silico-Spiegel contains manganese 17 to 22 per cent., and silicon 6 to 12 per cent The standard is guaranteed as follows:—

Manganese ... 18 to 20 per cent.
Silicon, 9 to 11 per cent., average 10 per cent.

A typical analysis, nothing but manganese and silicon guaranteed, is as follows:—

Manganese	20.32
Iron by difference	68 02
Silicon	10.33
Carbon	1.26
Phosphorus	0.07
Sulphur	—

It is sold per ton, 2,240 lbs.

* Abstracted from an article on "Grading Pig iron, Ferro-Alloys, and Coke" in "The Iron Trade Review."

Special High Silicon contains over 40 per cent. silicon. It is guaranteed 50 per cent. silicon, with an allowance of $1.75 per unit either way. The other elements are not guaranteed. A typical analysis is: —

Silicon	49.90
Manganese	0.16
Carbon	0.55
Phosphorus	0.075
Sulphur	0.018

It is also guaranteed 75 per cent. silicon, with an allowance of $2.50 per unit either way. It is sold per ton, 2,240 lbs.

Bessemer Ferro-Silicon.—This runs 8 to 16 per cent. in silicon, the price usually increasing or decreasing $1 per unit.

The "Domestic" is guaranteed silicon as specified 8 to 16 per cent: —

Phosphorus	not over 0.10
Sulphur	not over 0.05

The "Foreign" is unguaranteed, but phosphorus and sulphur, while unguaranteed, run very low. It is sold per ton, 2,240 lbs.

Ferro-Sodium is usually sold with 25 per cent. metallic sodium, and free from lime or excess of carbon.

Spiegel, Spiegeleisen or Mirror Iron contains 10 to 40 per cent. of manganese. The standard is guaranteed: —

Manganese, 18 to 22 per cent., average 20 per cent.	
Phosphorus	0.10 or under.

The silicon limits are sometimes specified, as it is desirable to know how same will run. A typical analysis, only guaranteed as above, is as follows: —

Manganese	20.50
Iron	73.61
Silicon	0.76
Carbon	5.18
Sulphur	0 002
Phosphorus	0 055

It is sold per ton, 2,240 lbs.

Ferro-Titanium.—The lower titanium contents is sold guaranteed only in titanium, which is 10 to 12 per cent., and is sold by the pound of alloy. A typical analysis is as follows: —

Titanium	11 21
Iron by difference	87.68
Carbon	0.67
Silicon	0.37
Phosphorus	0.04
Sulphur	0.03

If higher in titanium, it is sold per pound of pure titanium contained, regardless of the percentage of other material, the titanium above being specified. A typical analysis is as follows: —

Titanium	51.30
Iron	44.18
Carbon	2.82
Manganese	0.08
Arsenic	1.12
Sulphur	0.047
Phosphorus	0.021
Aluminium	0.41

Ferro-Tungsten is sold per pound per unit of tungsten contained, the price increasing with the increase in tungsten and decreasing with the increase in carbon. A typical analysis, the tungsten and carbon only being guaranteed, is as follows: —

Tungsten	85.47	61.20
Iron	13.90	33.02
Carbon	0.30	2.97
Silicon	0.13	0.47
Manganese	0.09	1.88
Aluminium	0.00	0.31
Phosphorus	0.019	0.04
Sulphur	0.025	0.03

Ferro-Vanadium is sold per pound at price per unit of vanadium contained, that is, if the alloy contains 20 per cent. vanadium and selling price is five cents per unit, it would cost $1 per pound of alloy. A typical analysis as made by one foreign company, vanadium alone being guaranteed, is as follows: —

Vanadium	36.0
Manganese	0.6
Iron	61.0
Carbon	0.4
Silicon	0.9
Aluminium	0.8

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METAL MELTING IN CRUCIBLES.

By Walter J. May.

Many metals and alloys must in ordinary practice be melted in crucibles, as the work does not permit of the profitable use of air furnaces of large size, while other metals at times have to be similarly melted to secure them from change of content as far as possible. This, of course, is generally acknowledged in the foundry, but a somewhat more extended view of the matter must be taken, as economy and efficiency must be considered if good melting is to be secured.

In general practice metals with very greatly differing fusing points have to be dealt with, but generally speaking copper is the most refractory metal in ordinary use in the brass foundry, this melting at about 2,000 degrees F. But where general alloying is done, more refractory metals than copper are used, nickel probably being the worst. Not only is heat of about 2,900 degrees F. required to melt pure nickel, but a much

higher temperature may be needed owing to impurities in the sample, and for this reason it is scarcely safe to deal with nickel unless a temperature of 3,000 degrees F. can be commanded. Taking the higher temperature metals, we get cobalt with about 2,200 degrees F.; copper, 2,000 degrees F.; gold, 2,290 degrees F.; cast iron, 2,200 degrees F.; steel, 2,550 degrees F.; wrought iron, 2,920 degrees F.; nickel, 2,920 degrees F.; platinum, 4,720 degrees F.; and tantalum, 4,162 degrees F., these heats being only approximately exact. Of course, the two latter metals are not in use in ordinary foundry work. In fact, when we approach or exceed 3,000 degrees F. in metal melting it may be taken that the limit of heat producible by the combustion of carbon in an ordinary furnace has been reached, and certainly much of the coke used will not enable such a heat to be obtained, and will not give heat enough for wrought iron or nickel.

To melt well and economically, it is necessary to have good furnaces, good fuel, and good crucibles. For coke either South Wales "patent washed," or the best North Brancepeth coke is very good, the former for brass foundry work, and the latter for the higher temperature metals; although generally speaking the harder North Country coke proves the more economical for all purposes when only one brand of coke is used.

With a well-built and arranged furnace with proper exit flue, sufficient draught provided, and the pit kept clear of ashes, good melting should be possible in the hands of any decent fireman. The object to be aimed at is to secure that the carbon shall be reduced to carbonic acid as far as is possible, and that the reduction to carbonic oxide shall be as small as can be managed. The calorific value of carbon reduced to carbonic acid is 14,500 B.T.U., but when reduced to carbonic oxide it is only 4,450 B.T.U., and for this reason, although the lower reduction cannot at all times be wholly avoided, it should be kept as low as possible. Each 1 lb. of carbon requires 2.66 lbs. of oxygen to reduce it to carbonic acid, and this means that at least 12 lbs. of air must be passed over and around the carbon to permit of the oxygen being provided; but as there is considerable slip in passing the air through the fuel, practically 18 lbs. of air per 1 lb. of carbon reduced must pass through the furnace, and as each 1 lb. of air has a volume of 13.14 cubic feet, this means that 136.52 cubic feet of air must be passed through for each 1 lb. of carbon consumed. If a furnace uses 100 lbs. of coke per hour, and the carbon content is 90 per cent., to get the highest efficiency 12,286.8 cubic feet of air per hour must be passed through the furnace. The air should pass over as much of the burning fuel in the bottom of the furnace as can possibly be managed, and to this end the pieces of fuel must be reasonably small; pieces varying from the size of eggs to those which will not pass through a 1 in. square meshed sieve will give the best results, all dust, of course, being removed. In addition to this, the firebars must be arranged to give the largest admission of air, and as a general rule, if bars of square sections made from ¾-in. bar iron be used, and these be spaced about 1½in. apart, the desired object will be secured, this, of course, being subject to local conditions.

Gas coke is not a good fuel for melting economically, although it is largely used, and where large crucibles are being dealt with particularly is this the case. The writer recently dealt with a case in which only three melts of brass of 300 lbs. each were obtained in 9½ hours, using gas coke in a badly designed furnace. By altering the furnace and using hard coke double the melts were eventually obtained.

With nickel and other high temperature metals special furnaces and crucibles are necessary, but for anything up to cast-iron, Morgan's "Salamander" crucibles will give satisfactory results with ordinarily careful working.

In melting, the fusing point of the metal or alloy being dealt with has to be taken into consideration, there being no advantage in using a greater heat than is necessary. In regard to this the melter should have some idea of heat as it is shown by colours. Approximately, the following table gives the temperatures of different heat colours, and as this may be of use for other purposes as well as melting, both the Centigrade and Fahrenheit scales are shown:—

Colour.	Centigrade Degrees.	Fahrenheit. Degrees.
Faint Red	516	960
Dull Red	700	1,290
Brilliant Red	800	1,470
Cherry Red	900	1,650
Bright Cherry Red...	1,000	1,830
Orange	1,100	2,010
Bright Orange ...	1,200	2,190
White	1,300	2,370
Bright White...	1,400	2,550
Incandescent White	1,538	2,800

Above and below these temperatures colour is no guide and either a pyrometer must be used, or the behaviour of the metals being fused must be the guide. In using colour tests for heat, copper

which melts at about 2,000 degrees F., only requires a bright orange colour inside the crucible to bring it down economically, although it can be brought to a state of ebullition—as when alloying it with lead—without injury. On the other hand, aluminium which melts at about 1,250 degrees F. only requires a dull red inside the crucible, and this must not be exceeded if the best results are to be secured. There is a peculiarity about this particular metal which should be noted, however, and that is the length of time it hangs before it drops, and this is not merely governed by the heat over the fusing point. For a time the bars of metal remain solid, and then drop with almost startling suddenness, and on pushing back the pellicle of oxide over the molten metal it will usually be noted that it is of a rich wine colour, at which temperature it is in the best state for pouring into the moulds.

All metals and alloys should be poured when they reach the required state of fluidity, as after this point is reached they are, from a moulder's point of view, deteriorating; while with alloys important changes take place when the crucibles are held in the fire while waiting for the moulds. For this reason the moulds should always wait for the metal instead of having the metal waiting for the moulds.

In some cases when making alloys the more refractory metals can be assisted by adding one of the lower melting metals at a certain stage. Take copper as an instance; at somewhere between 500 degrees F. and 750 degrees F., this metal will granulate with slight pressure, and if at that stage tin is added, the mass fuses and alloys at a far lower temperature than would be required to melt the copper by itself. This saves both fuel and metal, while it saves time pretty freely, and when making simple bronzes it is worth remembering.

Some metals rather difficult to melt by themselves come down very freely when immersed in a bath of molten metal of another kind, and such things as wire, wire gauze, and foils will melt readily without undue waste when plunged into a bath of molten metal, although by themselves they will burn away rather than melt.

As a general rule the crucible furnace over the fire should be free from oxygen, because at a certain temperature—differing with each metal and alloy—the metal absorbs oxygen very rapidly and becomes itself reduced to oxide, in which state it is of no value to the metal caster. But, while such a deoxidising atmosphere should be present, it does not always follow that such is actually the case, and to as far as possible overcome difficulties in the way of excessive oxidisation, the metal charged into the crucibles should be broken up small and the whole charge should be covered with granulated charcoal. Powdered charcoal is not necessary although largely used, because if the grains are, say, of the size of wheat grains, it proves quite effective and is more readily cleaned off the molten metal than fine powder. Coal gas is almost an ideal material to melt under, but would scarcely be used in ordinary practice, owing to the careless manner in which such things are usually handled. But given a gas free from sulphur even silver can be melted practically free from oxide, and the cost is not great, as 3 or 4 cubic feet per hour would be ample for a 2-cwt. crucible, while much less could not be used for crucibles of smaller size.

Gas-fired furnaces are not largely used in general work, although some are in evidence, while tilting and other mechanical furnaces do not appear to be so largely used as they might be, but probably this is on account of their high cost as compared with the ordinary built furnaces. Still, when one has examined a well-arranged tilting furnace having a forced draught, it must be apparent that it possesses possibilities for using, and economies in working, which makes the first cost rather a minor point when annual results are considered.

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SHORT WEIGHT SHIPMENTS TO FOUNDRIES.

THE report of a meeting held in Philadelphia, March 18, 1908, to deal with the question of short weights in pig-iron shipments, had been filed with Mr. A. Carpenter, chairman of the committee appointed by the New England Foundrymen's Association. The Philadelphia meeting was attended by representatives of consignors, transportation companies, and consignees of pig-iron, coal, and coke. The report says:—

"The question of discrepancies in shipping and outturn weights of pig-iron, coal, and coke was taken up. The discussion of the various topics covers an extensive range, but under the circumstances, there being present at this meeting representatives of so many diversfied interests—foundrymen, rail and

water transportation companies, and coke and iron-producers—it was impossible to pass any formal resolutions harmonising the views of all present regarding the outcome of the day's discussion.

"In a general way, however, it may be said that an understanding was in a measure arrived at with some of the transportation interests and shippers, particularly regarding coke, whereby methods of check-weighing might be employed to meet the railroads' requirements to establish losses of material in transit, and also to establish the correctness or incorrectness of the marked tare weight on cars. The representatives of transportation interests declared that, to obtain a check weight establishing a loss of coke in transit it would be necessary for the consignee to use the same methods in weighing at delivery point as at the shipping point. Cars must be weighed on railroad track scales by representatives of the railroad company and the marked tare used as the light weight of the car. Errors in marked tare may be arrived at by the same method of weighing, after the car has been cleaned out to the satisfaction of the railroad company's representative. A number of the representatives of the transportation companies expressed a willingness to allow for shortages, if established to their satisfaction by approved methods, and after such allowances had been made by the railroads, the shippers (where railroad weights govern the shipment) expressed a willingness to reimburse the consignee for shortages in material delivered.

"As far as overcoming discrepancies in the short weight of pig-iron is concerned, little of particular interest was accomplished. The discrepancies in all-rail shipments did not appear to be very extensive, and when such did occur there seemed to be little difficulty in making an adequate adjustment. In rail and water shipments, however, it was impossible to obtain from the representative of this interest any definite statement which would lead to the solution of the difficulty in shipments of that class."

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MESSRS. YATES, HAYWOOD & COMPANY, and the Rotherham Foundry Company, Limited, have decided to wind up the Company, as it cannot, by reason of its liabilities, continue business. Mr. Watson and Mr. Sully have been appointed joint receivers.

A TILTING CRUCIBLE MELTING FURNACE.

A NEW tilting crucible furnace in which the crucible is not removed for pouring, has been placed on the market by the Rockwell Furnace Company, New York. The accompanying illustrations show the chief points of interest.

In pouring metal from this furnace, the crucible is not disturbed, but remains fixed in its regular position, the metal being transferred to the moulds by means of a heated ladle or crucible, as preferred. After the first heat the metal is always charged in a hot pot, which greatly facilitates the melting process. In case of the crucible breaking, the metal does not run to the floor, but is retained in the furnace, and the melting may be continued until the proper temperature is acquired, when the metal may be taken to the moulds in the ordinary way.

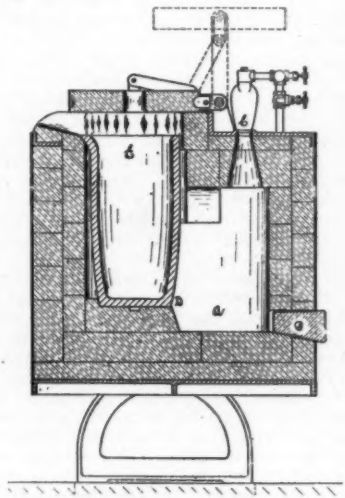

FIG. 1.—SECTION OF THE ROCKWELL CRUCIBLE FURNACE.

The burner, which is operated with a fan blast at a pressure of 12 ozs., is practically noiseless. Either oil or gas fuel can be employed. The burner is located at the top of the heating chamber, and the flame is projected downward against the bottom of the chamber and not against the crucible, which thereby is ensured a maximum life. There should be no anxiety over the use of thin crucibles, and no necessity of discarding them until

the break actually comes, which means a net saving of several heats. The furnace is easily relined with simple and inexpensive fire tile.

As any air pressure from 12 ozs. to 2 lbs. can be used, this furnace can be operated with any available air and oil system which may be employed in supplying other furnaces, a feature which obviates the necessity of high pressure compressors or positive blowers.

The cover is manipulated by a lever conveniently located at the rear of the furnace, where a pin and ratchet arrangement holds the door rigidly in any required position. The crucible can be covered after pouring without returning the furnace to an upright position. While the blast is on, heavy pieces of metal may be fed to the crucible through the opening in the cover, as the waste heat passing through melts it down into the crucible rapidly. The furnace is tilted by means of a worm and wheel, operated by bevel gearing from the hand wheel.

Where it is essential that the heated gases in the furnace should not come in contact with the metal, a cover may be put on the crucible to protect it. This, however, is unnecessary for ordinary work, as scrap yellow brass stampings from the ends of safety pins have been melted hot enough for pouring very light castings with a loss of but 3 per cent., the only precaution while melting being to cover the metal with a few pieces of hard coal.

The number of heats per day will vary from 3 to 10, and the amount of fuel required will range from 1½ to 3 gallons of oil, 210 to 420 cubic feet of natural gas, 315 to 630 cubic feet of illuminating gas, 675 to 1,350 cubic feet of water gas of 300 B.T.U. per cubic foot. This varies according to the quantity and quality of metal melted, the heat at which the metal is required, and the attention and promptness with which it is melted and poured. The furnaces are at present made in four sizes of a capacity of 200, 375, 800 and 1,100 lbs. respectively. The floor space required by the smallest size is 41 by 64 in.; by the largest, 50 by 74 in.

FIG. 2.—FRONT VIEW.

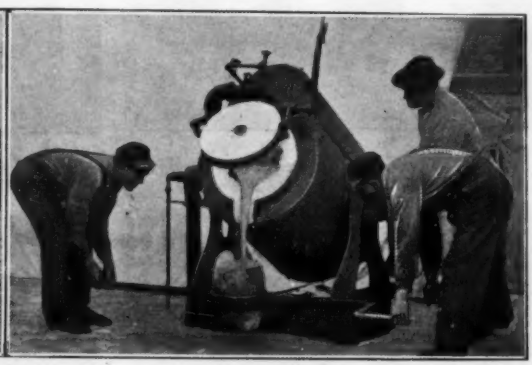

FIG. 3.—POURING.

ROCKWELL TILTING CRUCIBLE FURNACE.

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HISLOP'S GAS PRODUCER.

THE annexed illustrations show installations of a new producer, the design of Messrs. R. & G. Hislop. When used in connection with a boiler, the producer is placed in front of the boiler, with the cleaning chamber in front. The fuel, which may be gas coke, or coal, or a mixture of coke and breeze, is put into the producer from the top, either directly or with a feeder, and is gasified in the usual way. The gases from the producer, together with the air, are mixed in the chamber or chambers placed in front of the boiler.

Cleaning is necessary once only in 24 to 48 hours, and steady steam pressure is obtained. Provision is made for shutting off the boiler at a moment's notice, and the whole arrangement is always under control.

The gases pass into combustion chambers constructed in the lower portion of the flue or flues, and from thence they

issue through specially formed screens at a high temperature. It will thus be seen that what was formerly the ash-pit or receptacle for ashes is now transformed into a reservoir of heated gases, thus increasing considerably the heating surface and power of the boiler.

The formation of the bottom of this producer differs from any other on the superior. The clinker is allowed to accumulate for 24 to 72 hours, depending upon the amount of ash in the fuel, or until the depth is such as to permit of tunnelling through from front to back of producer. The arch of clinker remaining, supported by the producer sides, sustains the incandescent fuel above during the cleaning process, and is broken

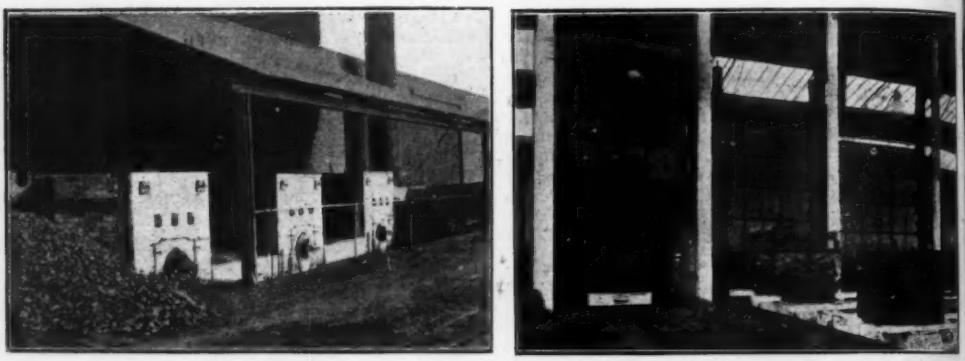


FIG. 1.—HISLOP'S GAS PRODUCER APPLIED TO THE HEATING OF CORE-DRYING STOVES.

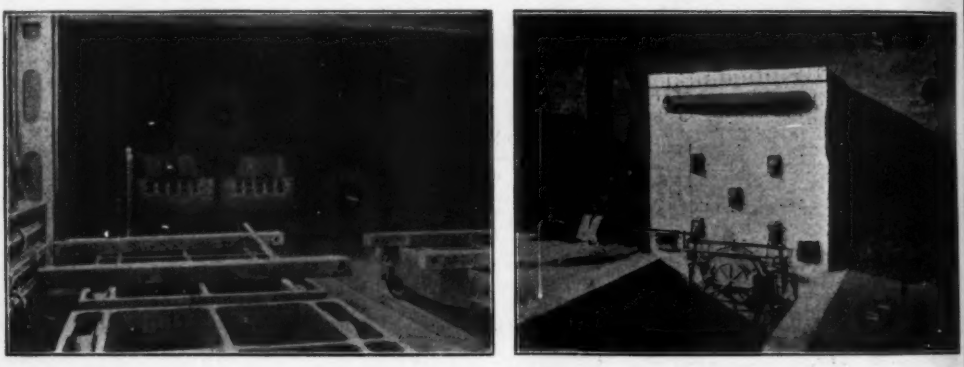


FIG. 2.—HISLOP'S GAS PRODUCER APPLIED TO THE HEATING OF A DRYING STOVE AT MESSRS. HARLAND & WOLFF'S, BELFAST.

market. The method of injecting the primary air into the producer is shown in Fig. 3. It is designed to secure uniform combustion of the fuel, and to prevent the escape of air up the sides of producer. Consequently, the quality of the gases is pure and constant. A feature is the method of cleaning the producer, which, compared with the loose bars usually employed, is greatly down from the top door on to the sole and allowed to lie until next cleaning time.

This producer has found an extended application for core ovens, for heating or drying stoves, plate and bar furnaces, etc. The saving in this case is claimed to be from 40 per cent. to 50 per cent., as compared with coal fires. Gas coke is used, and, as a rule, the cost of same is

from 3s. to 4s. per ton cheaper than coal, this alone securing a return of about 33 per cent. on the initial outlay. Heat for heat, this arrangement will, it is said, effect a saving of about 50 per cent. of fuel, or weight for weight of fuel, it will give about 50 per cent. greater heat.

At the Paisley Foundry of Messrs. Bow, McLachlan & Company, Limited, where several Hislop patent gas producers are in use for heating the drying stoves, there is no difficulty in maintaining a temperature of 650 degrees Fahr., with a consumption of about ½ to ¾ cwt. of ordinary gas works coke per hour. There is at the same time less cracking of the moulds and cores, and an entire absence of dust and smoke. The

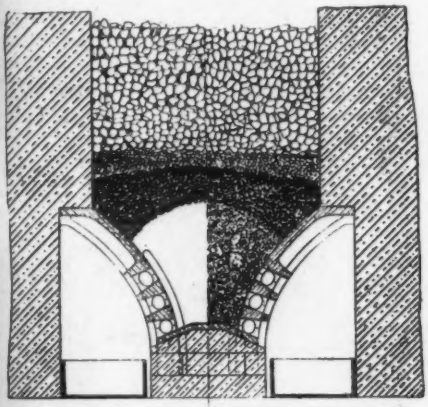


FIG. 3.—HISLOP'S GAS PRODUCER. METHOD OF INJECTING AIR.

producers are well under control, and are capable of producing any degree of heat required. They are easily managed, only needing a supply of fuel every four to five hours, and a cleaning once only in 24 to 48 hours. When work is suspended from 12 to 24 hours the producers require little fuel and attention.

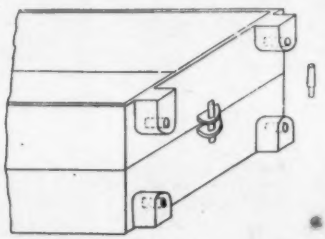
At the same works, in the plate furnace, which is 18 ft. by 6 ft. by 2 ft. 3in., and the bar furnace, which is 40 ft. by 2 ft. by 2 ft., each heated by one producer, and using about ¾ cwt. per hour of ordinary gas works coke, a temperature approaching the melting point of cast-iron is easily maintained.

The producer is in use at the Fairfield Shipbuilding Works, and also at those of Messrs. John Brown & Company, Harland & Wolff, Glenfield & Kennedy, D. Y. Stewart & Company, Bathgate Foundry, and other works.

GUIDE PINS.

WHERE boxes are in constant use it is good practice to make the guide pins fixtures, both for hand and crane boxes. For the latter the pins should be at least 1½ in. in diameter, which allows for a strong shank after turning down for the shoulder. All holes should be drilled, the pins fitting tight in the bottom box, with an easy fit in top box. With pins fitted in this way there should be little danger of twisting or overlapping at the joints. Where it is considered inadvisable to make the pins a fixture, owing to expense, etc., the pin shown in the sketch can be used. The holes in all boxes should be drilled accurately to a template so that they can be interchangeable.

The top part of pin should be parallel, the shank tapered, and the holes in bottom box reamed out to suit. After closing the mould a light tap on bottom of pin will



GUIDE PINS.

release it, thus avoiding the trouble of looking for pins when they are nearly all in the drying stove. Where it is the practice for dry sand work to use screwed pins in cored holes, a great deal of time is wasted in finding suitable nuts, washers, etc.

In the sketch is also shown a way of providing handles for two-handed boxes which are not likely to be in the way at casting time. The usual slip or draw print is put on the pattern, but a core is put in instead of handles, which can be provided loose. The sketch shows the projection made to draw, but if wanted round, a block print could be put on, and the projection made in a core with the smaller core set in place.

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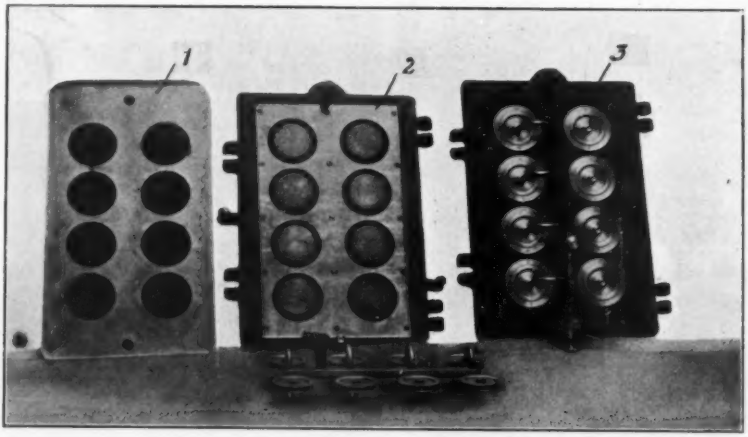
THE ADDERLEY BRASSFOUNDRY COMPANY, of Vauxhall, Birmingham, have acquired the goodwill, etc., of the business of Mr. C. F. Nutting, brassfounder, 23 and 50, George Street Parade, Birmingham.

MOULDING TROLLEY AND SIGNAL WHEELS.

THIS arrangement for moulding signal rollers, trolley wire wheels, etc., consists of a two-parted core-box (1 and 2), also a pattern-plate (3). The pattern-plate is made from split patterns, and both boxes are moulded from the same plate. One main runner is provided, with gates on one side only, so that the making of the pattern-plate is a simple matter. The pattern-plate and core-box are fitted to the two sides of the revolving plate of an ordinary turn-over moulding machine, and the first operation is to make both half-boxes from the pattern-plate. The cores



ARRANGEMENT FOR MOULDING TROLLEY AND SIGNAL WHEELS.

are then made, and on the core-box the bottom half mould is placed—after first removing part 1—and turned over, which lays the cores in their correct positions in the mould.

The hub of the wheel is centred on one side in the act of moulding, which saves the time subsequently taken to locate the centre point. With other methods, when the hub is supplied with gates on both sides, this is not possible. No movement of the half patterns is possible, and consequently there is no overshut. Further, there is no seam in the groove, which is a special advantage when making signal or trolley wire wheels.

A high output is obtained from the arrangement, which was designed, and is supplied, by the London Emery Works Company, of Park, Tottenham, London, N.

NOTES ON FOUNDRY PRACTICE.

FROM a pamphlet issued by Ludw, Loewe & Company, Limited, we take the following:—

Few manufacturing engineers realise or recognise the value of securing suitable qualities of cast iron for constructive purposes, or of the necessary preparation of the surfaces of castings for workshop operations.

Selection of Iron.

It cannot be denied that the selection of an iron of suitable strength and hardness is a most important factor in manufacturing costs. If an iron that is liable to chill be used for small castings, the product will be so hard as to be difficult or impossible to machine, while the same iron cast in large masses would perhaps be soft and easy to work. In determining the kind of iron to use, due consideration must therefore be given to the weights and thicknesses of the intended castings, as well as to the use to which such castings are to be put, especially when their surfaces are to be machined. Anything, for example, is good enough for rough balance weights that do not require to be machined, but for steam engine cylinders and the working surfaces of machine tools the best results are only to be obtained with material specially mixed for the particular end in view. The importance of uniform hardness in castings can hardly be over-estimated for the reason that speeds and feeds

are limited by the hardest castings, which are the most difficult to machine. When castings run hard and soft, the softer material, perhaps quite hard enough for the purpose in hand, can only be machined at the same rate as the hard material, because the speeds and feeds of the machine are fixed by the hardest material, and no advantage is gained by having a proportion of softer castings, as it is not practicable to keep changing the machine adjustments. When all castings are uniformly hard or soft the machining can be done at the maximum safe speed for that hardness without danger of breakage or excessive wear of cutting tools.

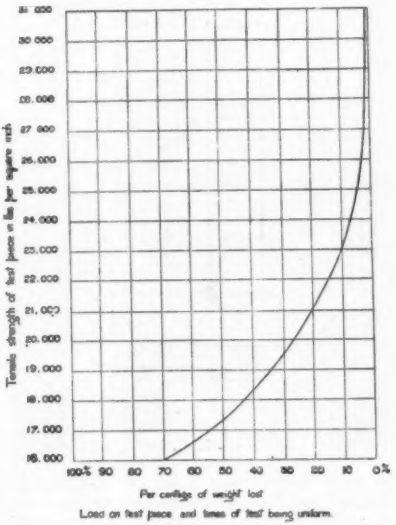


FIG. 1.—CURVE CO-ORDINATING THE RELATIONSHIP BETWEEN THE TENSILE STRENGTH AND THE WEARING PROPERTIES OF CAST IRON.

To determine the relation of the wear of iron and its hardness a series of tests were made by rubbing cast-iron cylinders on a hardened steel die. The test pieces were ¾ in. in diameter and 1 in. long. They were carefully weighed before and after the test and were rubbed for equal times under a uniform pressure. The diagram, Fig. 1, shows the results of these tests. From this diagram it appears that the wear of soft cast iron of 16,000 lbs. tensile strength is considerable. It also shows that the slope of the curve changes quickly, and at 31,000 lbs. has become practically vertical, while at 23,000 lbs. the wear is very small, not exceeding one-seventh that of the soft iron. We use iron of a tensile strength of 26,000 lbs. for our machine beds. This has wearing qualities but little less than the hardest iron shown on the diagrams, whilst possessing qualities of machineability much superior.

Chemical Tests.

To obtain this regularity of product it is essential to know, by means of chemical and physical tests, as nearly as possible the composition and other properties of the raw materials employed, because the ultimate quality of the castings depends, not only on the pig or scrap employed, but on the quality of the coke, its freedom from sulphur, and so on. The presence of sulphur in the coke determines, to a large extent, the presence of that element in the castings. A sulphurless iron may result in castings heavily charged with sulphur if the coke be sulphurous. For example, in certain castings made from a pure pig-iron containing less than 0.02 per cent. of sulphur, the final sulphur has been sometimes found to be as high as 0.11 per cent. due to absorbtion of sulphur from the coke. It is thus of the utmost importance to employ as little coke as possible, for it is from the coke that iron obtains a great part of its sulphur. One great advantage of a chemical laboratory is the freedom from the use of particular brands of iron that it confers. The whole market is thrown open to the founder who can simply buy his irons by their chemical analysis, and so mix them as to secure the results he wishes. In our own works we have gradually established fixed specifications for our material, as experience and investigation have shown us what is best for our work. The subjoined table shows the results we aim to secure in castings for fairly light machinery. In the thinner and lighter parts it will be observed that silicon is desired in larger quantity than in heavy pieces, because it is necessary to employ a fluid iron for small parts, and silicon promotes fluidity, as also does phosphorus. Sulphur in excess is an objectionable element, because it tends to produce blow holes, hardness and brittleness, but a certain amount is necessary in order to produce castings that will give a good, smooth, clean machined surface, free from small porous spots, and to regulate the proper amount of combined carbon in the castings. It is therefore allowable within reasonable limits, and these limits we have fixed from experience at from 0.07 to 0.12 per cent. according to the weight of the casting. In the cupola, the tendency is for the proportion of silicon to become less, while that of sulphur tends to increase. It is therefore

provided that the pig and scrap charged into the furnace shall be richer in silicon than the desired castings, whereas the original percentage of sulphur must be kept lower so as to avoid final excess. This oxidation of silicon is not a fixed proportion of the silicon charged, but varies with the design of cupola employed, the method of charging, the blast pressure, and even the size and percentage of scrap charged. We find it necessary to work out the silicon loss for each cupola in our foundry so as to proportion the correct charge, for this loss will vary from 5 per cent. to 15 per cent. of the calculated silicon in the charge. Experience shows that it is practicable so to proportion mixtures as to secure a result in silicon within 0.10 per cent. of the desired amount, sulphur within 0.015 per cent., and other elements within desired limits. To secure this end an analysis is made every morning for sulphur, silicon and combined carbon from the transverse test bars of the preceding day's melt, and any necessary corrections are made to keep mixtures within limits by adding to such scrap suitable new stock for the current day's work. In the purchase of pig-iron each lot is sampled and analysed and its record kept. Too much stress cannot be laid on the proper sampling of the purchased pig-iron. We take ten representative pigs from every carload of ten tons. We drill these and weigh out an equal weight of drillings from each pig. We grind these drillings together in a mortar and make our analysis from these mixed drillings. Our experience teaches us that this is the only practical way of securing an average result for the carload lot. The day's mixture is then made up from the various lots as required, and experience teaches that widely different irons can be freely purchased and so blended as to give good results.

Physical Tests.

In addition to the chemical tests it is also desirable to make physical tests on specimens cast from each melt. For the tensile test bars are cast in green sand; they are cut to a length of 256 millimetres (say 10 in.), and have a diameter of 27 millimetres (say 1 1/16 in.); they are turned down

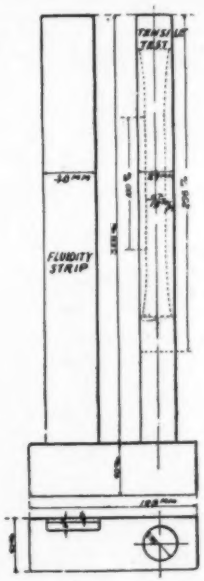


FIG. 2.

centrally over a length of 100 millimetres parallel (say 4 in.), and 15 millimetres diameter ($\frac{19}{32}$ in.); beyond the parallel length the turned part is tapered gradually up, as shown in Fig. 2. These test bars show from 22,500 lbs. breaking stress per

A.—Mixture for thin castings of thickness under ¼ in.		B.—Mixture for castings of an average thickness of ½ in. for machined parts.		C.—Mixture for castings of thickness from 1¼ in. to 2 in.	
Limits allowed.	Analyses desired.	Limits allowed.	Analyses desired.	Limits allowed.	Analyses desired.
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Silicon ... ... 2.45 to 2.65	2.55	2.30 to 2.50	2.40	2.15 to 2.35	2.25
Sulphur ... ... 0.07 to 0.10	0.08	0.07 to 0.10	0.09	0 08 to 0.12	0.10
Manganese ... ... 0.30 to 0.70	0.40	0.30 to 0.70	0.40	0.30 to 0.70	0.40
Phosphorus ... ... 0.70 to 1.00	0 90	0 50 to 0.90	0.70	0.40 to 0.80	0.60
Combined carbon ... 0.30 to 0 50	0.40	0.30 to 0.50	0.40	0.30 to 0.50	0.40
Graphite ... ... 2.90 to 3.20	3.10	2.90 to 3.20	3.10	2.90 to 3.20	3.00

For very heavy castings a mixture containing about 2 per cent. of silicon may be used; other elements the same as mixture C. For castings under ¼ in. thick a proportion of 3.50 of silicon will produce the softest castings, above this point the hardness gradually increases and a surface chill will occur when silicon reaches 4 per cent. In this respect our experience does not coincide with that of certain authorities who have claimed 3 per cent. as the upper limit of softness.

square inch of cross section for mixtures A and B, while mixture C gives from 24,500 to 27,500 lbs. Other bars are cast 26 millimetres square (say 1 in.). They are placed on supports at 300 millimetres (say 12 in.) apart, and are loaded at the centre. They break at 2,200 to 2,500 lbs. for mixtures A and B, and at 2,500 to 2,700 lbs. for mixture C, the specimens deflecting 0.10 in., 0.9 in., and 0.8 in. respectively. These square test bars are cast

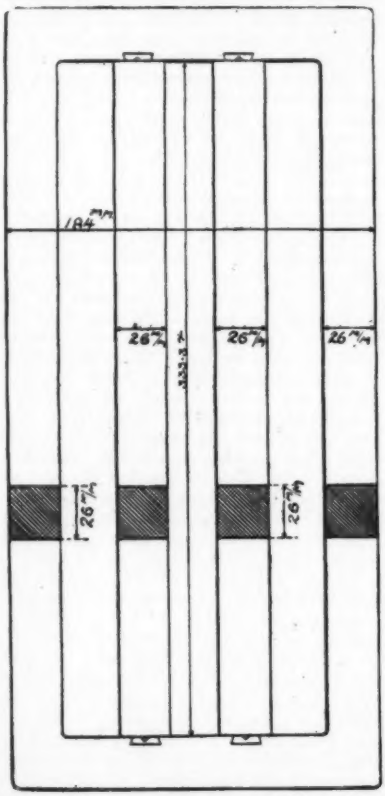


FIG. 3.—FRAME FOR CASTING CONTRACTION BARS.

in a frame (Fig. 3) exactly 333.33 millimetres in length, and are measured in another frame for contraction by means of a wedge scale (see Fig. 4). It is important to know this quality of the metal because it is desirable that iron with a large co-efficient of contraction should not be employed for castings of complicated form, or for those which have considerable and sudden differences of thickness on adjoining parts. By comparing chemical analysis with physical results, the causes of objectionable features can be traced and avoided. The three mixtures above-named give contractions, as follows:—

A. from 0.8 to 0.9 per cent.
B. ,, 0.9 to 1.0 ,, ,,
C. ,, 1.0 to 1.1 ,, ,,

The contractions aimed at are 0.8, 0.9, and 1.0 per cent. Many founders use the contraction test alone for regulating mix-

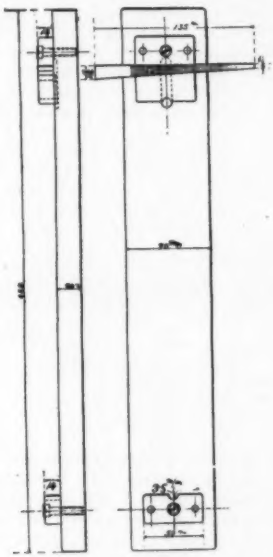


FIG. 4.—FRAME FOR MEASURING CONTRACTION BARS.

tures, but our experience teaches that it is not to be relied on, especially when using a mixture of low total carbon contents. It does roughly indicate the amount of combined carbon, and can perhaps be used for this purpose where only one mixture and one class of castings are made, but it is liable to give false results from the first ton or two of metal melted, and from the last ton taken from the cupola on a two hours' run. The contraction is largely affected by the temperature of the cupola, being greater when starting with cupola cold, and falling below normal when the cupola is thoroughly hot. Contraction is, however, not much influenced by the temperature of pouring, or by the condition of the mould. Tests made with

very hot, medium, cold and very cold iron show respectively, 3.29, 3.23, 3.16, and 2.92 in a length of 300. The very cold iron was so cold and sluggish that no moulder would expect to get a perfect casting. In exceptional cases we have found the same contraction from mixtures of the same brand of iron, having the same analysis, except that the silicon differed by as much as 1 per cent. To ascertain what tendency any mixture may have to chill in casting, chill blocks of the form shown in Fig. 5, are cast in green sand, and are afterwards broken through the thick and through the wedge-shaped portions, and the depth of chill measured. While A iron chills from 0 to 0.5 millimetre, B iron chills about 0.5 millimetre, and C iron averages 1 millimetre. The first two irons must not exceed 0.75 millimetre, and C must not exceed 1.5 millimetre in these small blocks; the amount, of course, in a large casting without the chill face being practically nil. Another important property to be ascertained is

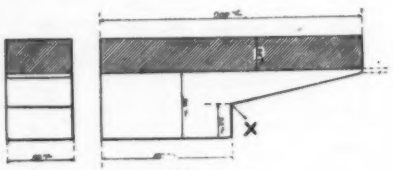


FIG. 5.

that of internal shrinkage, or the tendency to pipe in cooling. If a block be cast of the form shown in Fig. 5, from iron with a tendency to shrink, this will be shown by the formation of a hollow at the point X. With the tensile test piece (Fig. 2) is also cast another test piece, which is a long taper strip diminishing to a thickness of 3 millimetres, and serves to determine the fluidity of an iron. The fluidity of the iron is measured by the length of this strip, a non-fluid iron refusing to flow to the extreme end and thereby demonstrating its viscous, non-flowing quality.

Mechanical Tests.

The hardness of an iron is tested by actually cutting it. For this purpose a number of standard test bars are made use of. A plain drilling machine with a weighted feed is fitted with an apparatus to revolve a paper drum at a slow speed. This drum revolves a certain distance for each 100 revolutions of the drill spindle. When no feed is on, a horizontal line is drawn upon the paper by a pencil when the drill is working. This pencil is so attached that it moves in a vertical line through a given distance that is proportional to the downward movement of the drill spindle. The resultant line drawn by the pencil is diagonal, and the angle of slope will vary according as the drill feeds more or less rapidly per 100 revolutions. In using the apparatus a standard test bar is first drilled, and a diagram obtained. Then the sample bar to be tested is drilled, and finally the standard bar is again drilled. Diagrams are taken for each of the three operations, and a line midway between the diagonals from the standard bar is the diagram of comparison. A deviation from this by the diagram obtained from the sample to be tested shows at once whether it is harder or softer than the standard, so that the mean of the two diagonals being the diagram of comparison, any deviation from this by the diagram of the sample to be tested shows the variation of hardness above or below standard. The double drilling of the standard bar is, of course, for the purpose of eliminating the effects of the dulling of the tool. The standard test bars are cast in dry sand and measure 40 in. by 2 in. by 1 in. When drilled with a newly sharpened drill a depth of 1 millimetre will be penetrated for each 11.46 revolutions of the drill. The paper drum and pencil are so connected that 2,308 revolutions of the spindle are shown by each 1 millimetre of vertical height, and 4.6 millimetres measured horizontally represents 1 millimetre of drilled depth. Thus the softest irons give the flattest angles. Our testing department has now acquired a large fund of valuable information in the shape of these physical tests in combination with the chemical analysis of the various tested bars. We use a flat drill for this test, of a diameter of 8 millimetres. It is made from a special tungsten water-hardening steel. Carefully made and ground, the wear of the drill is slow and steady, and it may be used for several hundred tests before re-sharpening. Our machine is improved from the original design of the late Chas. A. Bauer, of Springfield. Mr. Bauer did not use a diagram, and he could thus obtain false results when the drill encountered a soft or spongy place. The diagram points out these irregularities.

Pickling.

Equally as important as the quality of the iron is its preparation by pickling for the purpose of removing the silicified skin and the loose sand which are so destruc-

tive of cutting tools and of the working surfaces of machines. The process is very simple. The castings are taken direct from the foundry, little or no pains being taken to remove any sand from them; they are laid in wooden troughs (see Fig. 6), and acid is poured over them several times daily, flowing back into the acid tank through the hole in the bottom of the trough. In the course of about 24 hours, more or less, the sand peels off and leaves the surface clean and free from grit. The acid mixture consists of commercial sulphuric acid diluted with seven to nine times its bulk of water. It is used over and over again, and is refreshed as needed by a further addition of acid. After the pickling is complete the plug which had previously closed the drain is placed in the hole above the acid tank, and the castings are simply washed down with water from a hose, which flows down the drain, finishing with hot water, which quickly evaporates and avoids rusting the castings. This removes all tract of the acid. The cost is very small, and the resultant saving in the machine shop is large. Cutters wear longer, machine tools can be run faster, and the absence of the sand and black dust that accompany untreated castings adds notably to the cleanliness of the workshop and of the men employed in it. The pickling process is not costly in either labour or material, for it dispenses with much of the ordinary work of the fettling department. Small castings, even though pickled, may still be tumbled with advantage to reduce their general sharpness, and to smooth the surface asperities, and also to relieve the castings of all internal stress and thus promote accuracy of machine work upon them. In tumbling castings it is useful to employ a quantity of hard wood blocks, as these give a better polished surface to the tumbled pieces.

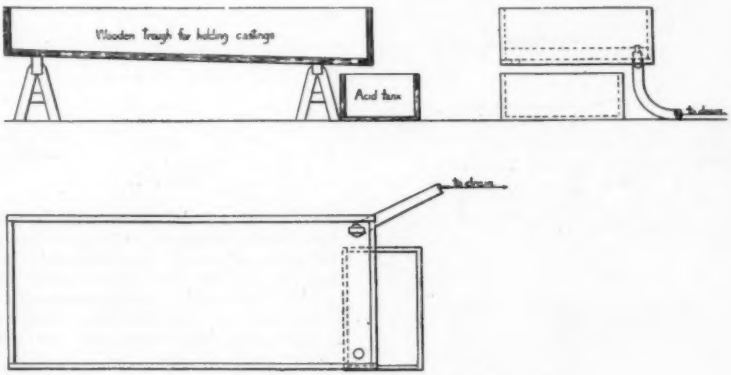


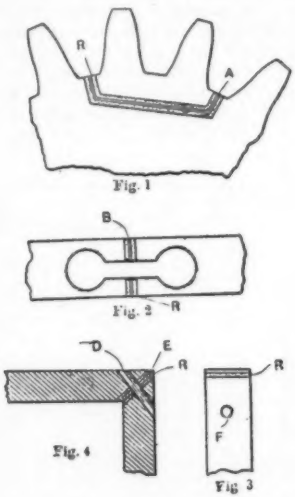
FIG. 6.—TROUGH FOR PICKLING CASTINGS.

METHOD OF REINFORCING BRAZED JOINTS.

THE difficulty of making a good brazed joint between two pieces of cast-iron or high carbon steel, particularly where the two sections were broken apart, has been chiefly due to the fact that the material used for brazing would not flow readily. When a casting is broken there is a weakening of the metal adjoining the fracture and if the break is repaired by brazing there is a tendency to fracture again on lines parallel with the original break. A method devised by the Richardson Cast-Iron Brazing Company, of Pittsburg, provides for inserting between the adjacent faces of the joint to be brazed a thin strip of metal, so that the brazing material will flow over its surface and attach itself to the adjacent surfaces of the metal to be joined. Reinforcing pieces are also employed, these crossing the fracture and being socketed in the metal on either side of the break.

In the illustrations of the method which are shown, R represents in each case the brazing material. Fig. 1 is a side elevation of a gear wheel in which two teeth have been removed and replaced by new teeth. A represents a strip of metal con-

forming to the shape of the joint. The parts are brazed to each side of the strip by means of a standard flux and a brazing material. Fig. 2 illustrates the method of repairing a broken bar. A joining strip B is employed, and in addition a reinforcing piece is socketed in recesses in the parts of the bar. The reinforcing piece is of steel, and the brazing material flows freely over its surface and tightly brazes it in the recesses. Fig. 4 shows a square frame that has been fractured at one corner. The reinforcing piece D is provided in a hole bored at an angle to the sides of the frame and through the joining strip. In Fig. 3 the joining strip F is shown in the centre of



REINFORCING BRAZED JOINTS.

the side of the frame. It is found that galvanised sheet steel can be used for the joining strips with the best results.

—o—

MESSRS. W. L. WOOD and J. S. BOYD, ironfounders, etc., Steventon, Berks., trading as Wood & Boyd, have dissolved partnership.

MR. A. JACK, late partner in the firm of Messrs. Marshall, Flemming & Jack, Delburn Works, Motherwell, has commenced business on his own account at the Whitegates Engineering Works, Motherwell, where he is trading under the style of Alexander Jack & Company.

MEANS FOR OBTAINING CHILLED CASTINGS OF COMPACT STRUCTURE AND FREE FROM TENSION STRAINS.*

OWING to the more stringent requirements made by consumers with regard to the structure of chilled castings, it is continually getting more difficult for the steel founder to give satisfaction and comply with all the demands advanced. The chief difficulties are encountered in castings of complex shape, since no generally applicable rules can be fol-

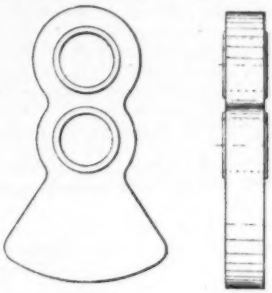


FIG. 1.

lowed, but special treatment is required for each casting, according to the shape, thickness of metal, etc., not only in making the mould, but also in the drying, casting and cooling. The composition and treatment of the moulding composition is just as important as the method

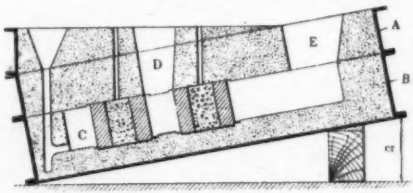


FIG. 2.

of ramming it and the provision of vents. Another point to be noticed is whether the chill mould is to be in an upright, inclined, or horizontal position, and whether the gate is arranged to correspond. The latter may be simply mounted on the mould, so that the metal flows down the full height of the mould, or the metal may be intended to flow upward, the gate being then arranged tangentially or forked. In the case of

* L. Treuheit, "Stahl und Eisen."

complex castings it is advisable, with a view to minimising strains afterwards, that the thickness of metal should be as uniform as possible throughout. Should this be impossible, arrangements should

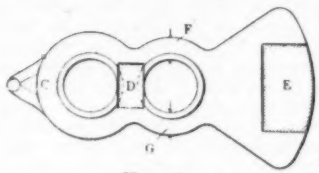


FIG. 3.

be made to ensure uniform cooling by providing a water-jacket at the places where the metal is thickest.

When the formation of shrinkage cracks is anticipated, the endangered parts should be strengthened by ribs; and tension strains in high ribs may be

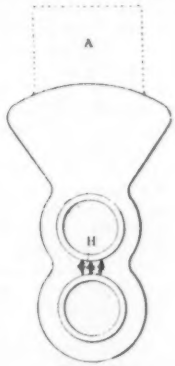


FIG. 4.

guarded against by recessing these parts. In places where two or three different sections meet, it is highly desirable, especially in castings destined for standing powerful hydraulic pressure, to lessen the accumulation of metal by recessing, this being the sole means of pre-

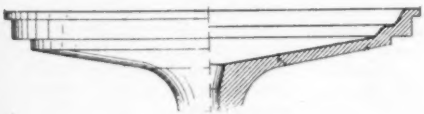


FIG. 5.

venting suction. The time of cooling in the chill mould and the subsequent hardening of the casting must be regulated with precision, in accordance with the chemical composition of the steel, particular attention being paid to the percentages of phosphorus and sulphur.

As already mentioned, it is extremely difficult to lay down general rules when the production of complex castings is in question. Hence, the following explanations relate to the precautions necessary to ensure compactness of structure and freedom from tension strains in casting complex pieces.

EXAMPLE 1.

Casting a Crank Sheet (Figs. 1-4).—In this case the best method of arranging the mould is in a double box, A and B

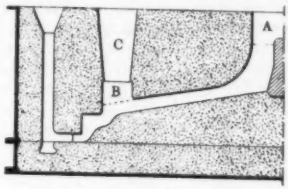


FIG. 6.

(Fig. 2). The casting gate passes through both boxes, and is branched at C (Figs. 2 and 3). Two flow-gates are provided, at D and E. The finished mould is mounted on the slope, with a pitch of about 16 in. It might be objected that in this case a single flow-gate would suffice if made

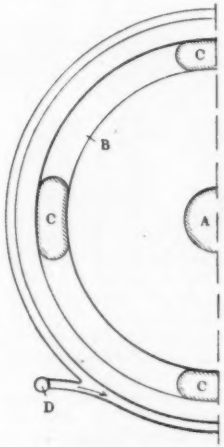


FIG. 7.

large enough. Experience has shown, however, that despite the slope of the mould and the provision of a large single flow-gate, there is always a tendency for cavities to form at H (Fig. 4), owing to

the constriction of the material at F and G (Fig. 3). The section is too small at these places to allow the liquid steel to flow down into the lower portions as the piece begins to shrink, and, consequently, there are formed cavities which can only be prevented by making a second nipple. If the piece were to be cast in the upright position shown in Fig. 4, a defective casting would result, even if a large nipple were left. The reason of this is that the parts F and G cool much quicker than the lower parts, and cavities would certainly be formed. This simple example, therefore, proves that the upright position is just as unsuitable in this case as the sloping position with only one flow-gate. Another point in connection with the casting of this crank is that the flow-gates should be of ample di-

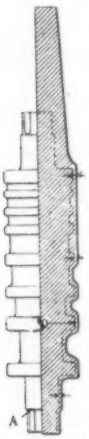


FIG. 8.

mensions, but short, so that the metal can settle down easily in cooling. With high and narrow flow-gates the shrinkage of the metal forms a hollow, which may extend right through the nipple down to the casting, the quality of which consequently suffers, and a troublesome process of welding may become necessary. In casting, the pouring should be stopped as soon as the flow of metal reaches the first flow-gate, the latter being then poured full of fresh molten steel. The same thing is done in the case of the other flow-gate.

Casting a Marine-Engine Piston.—An example of an operation in which the method of arranging the pouring-gate is important to the success of the casting, is afforded by a marine-engine piston (Figs. 5, 6, and 7). This is usually moulded with the aid of templets. Pistons measuring less than 40 in., outside diameter, should have a nipple at the upper end, A (Fig. 6). Pistons of larger dimensions should have flow-gates at the rim B (Fig. 6), and at the top, A, the former in the shape of an annular slag crown B, 4 to 6 in. high, with a series of openings, C, at intervals all round. The pouring-gate D is arranged tangentially at the outer rim, as shown in Figs. 6 and 7, so that the molten metal entering the mould has a rotary motion, so that all bubbles and impurities are driven upward by the whirling metal into the nipples, and a more compact and cleaner casting is obtained. In casting by this method it is not necessary to leave a larger margin than about two-fifths of an inch for trueing up. At the same time, the casting cools in a fairly uniform manner, since the thick hub receives cooler metal than the thinner rim and bottom of the piston. In large pistons, over 40 in. in diameter, the only parts where the casting requires to be freed afterwards are at the nipple and the rim-gates in the upper box. There is no need to free the part in the bottom box, even with large castings, since the mould for the bottom box has to be arranged so that the casting can shrink without the moulding compo. having to be knocked loose. If the lower part of the casting were freed, the upright position of the two boxes would cause the casting to warp; and if liberated too soon, the still liquid metal in the flow-gates would run out and endanger the compactness of structure. Premature cooling with water often causes deep cavities at the hub, and for this reason water-cooling is not recommended.

Casting Rolls (Fig. 8).—This example is intended to illustrate the possibility of dispensing with cooling insets and preventing the so-called worm marks. The mould is made with rotary templets, as in the case of a piston or cylinder head. Some founders ram the two halves of the mould boxes full of compo., so as to turn the mould out of the mass by means of the templet, and then sleek the surface with a sleeking tool (old method). In other foundries the mould is filled up with firebrick so as to leave only about a 2-in. layer of compo. to be shaped. Both methods are imperfect, do not take into consideration the shrinkage of the roll after casting, and generally result in the formation of transverse cracks, where there is any considerable difference in the grooves, though they are practicable when the grooves are fairly equal. It is better, however, to

ram the two boxes with ordinary moulding sand and hand mallets so full as to leave only a space about the thickness of two fingers for the compo. The latter is beaten firm with a wooden mallet, and faced with thin sleeking compo. (slip) by means of a templet. In hammering the moulding sand, coke should be laid under the projecting flanges of the roll, so as to provide for the shrinkage. An important point is the provision of plenty of air vents, to allow the gases to escape, as this provision will prevent the formation of worm marks (smooth, tendril markings, from ¼ in. to 1 in. in length and over, caused by the liberation of air, or as a result of reactions in the bath of metal). It has not yet been found possible to entirely prevent the formation of these markings, which, however, only occur in thick castings: but they can be minimised by suitable precautions. For instance, the metal should not be too hot, the temperature being such that the steel will just flow nicely and fill up the mould. Another point coming under consideration is whether the metal should flow up or down, and whether it should be poured quickly or slowly. It can be observed that thick castings, rolls especially, are less subject to worm marks when cast with an upward flow of metal, suitable venting, appropriate pouring temperature, and quick pouring. Rolls cast by pouring from the top show the largest number of worm marks, owing to the spurting caused by the impact of the falling metal on that already in the mould.

The nipple should be at least one-third the total length of the roll, and taper towards the upper end, as shown in Fig. 8, so as to permit of ready contraction in a downward direction as the roll shrinks. Owing to the worm marks and the presence of impurities, the margin left for trueing up should always be twice as large at the top end as at the bottom (see Fig. 8). It is also advisable to bevel or round off the upper edges of the flanges, to enable impurities to rise to the nipple instead of hanging in the corners.

As soon as the molten metal rises into the flow-gate, the latter is filled up by pouring in fresh metal, so as to enable the latter to effect its purpose more easily. The lower neck, A, is cast in trefoil form, whilst the upper one is left full for shaping afterwards.

In many steel foundries it is the practice to insert cooling bodies of cast steel or rail ends, etc., in the mould just before pouring, in order to prevent the sucking of the steel. This practice, however, is technically wrong, since it impairs the tensile strength of the steel, for the cooling pieces are never fully dissolved; and however well they have been filed or pickled, they always get covered with a crust of oxide, and do not coalesce properly with the molten metal. They also get covered with bubbles and particles of slag, as can be shown by examining broken rolls. In fact, the practice has brought cast rolls into discredit, and led to their being replaced by forged rolls. If, however, a sufficiently long nipple be left, and the mould filled up several times with molten metal, the rolls will stand any comparison with those produced by forging. After the mould has been filled up for the last time the two sides of the box should be opened about ½ in., by wedges, at the top, to allow the roll to shrink freely.

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CASTING PINIONS AND WORM GEARS IN BRASS.

By J. Clements.

The casting of pinions of various kinds and also worm wheels and gears has been for years with many foundries a vexed question. First, because of the intricate

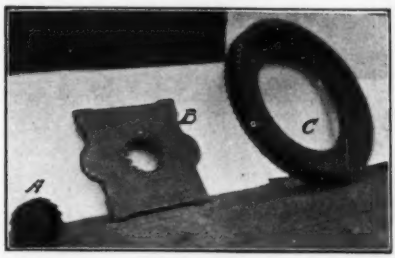

Fig. 1.

nature of the work, and also on account of the relative high cost of such productions. As far as the foundry is concerned, often only the best moulder receives the patterns for such, but with the more up-to-date methods of which I am about to speak, the making of all kinds of gears is not by any means formidable.

Take for our first example a small pinion (A, Fig. 1) with the teeth on the twist. The moulder at the bench first takes the pattern and rams up the same, following with the other side in succes-

sion, upon the first being turned over and the pattern board being removed. He takes off the second side that has been rammed up with a runner stick in position according to where it is to be gated from, in many cases from the hub or centre; then with the aid of the plate (B, Fig. 1), which is simply placed over the pattern, the pattern is drawn through. The plate guides the pattern and acts as a stripping plate does on a moulding machine, with this difference that the pattern in coming through the plate is at the same time turning round according to the curvature of the pinion teeth. I might here say that with the pattern in means a hard and fast way, but may be modified according to circumstances.

In (C, Fig. 1) will be seen a pattern assembled of a worm wheel. The teeth are of an irregular or concave shape, which accounts for the pattern being made in two halves for drawing from the sand. This class of pinion is used for small motors, and requires to be cast in a fairly tough, and at the same time hard, metal.

A three-parted box is required, the centre part having the teeth. If there should be many of these castings to make it will be well in the first instance to have a match or oddside before commencing operations. Otherwise, one-half of the pattern requires

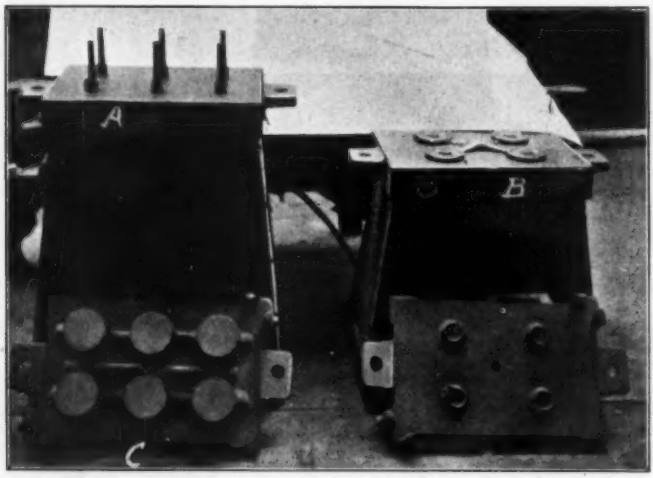

Fig. 2.

hand the plate for drawing this has to be made in the following manner. Upon the first or drag side being made and turned over, the pattern then being in position to draw, the sand in and around wants removing to the depth of about ¼ in., or preferably the same depth can be taken off all round the teeth, allowing a plate of white metal to be run to the above depth. This is really the stripping plate, and when run in is lightly rapped, or the pattern treated in a similar manner, then taken off and slightly eased for use. It should be marked in a manner to correspond exactly, and be used to draw the pattern through in the same place as run, as however carefully the pattern has been made there will be some difference in the plate or pattern in different parts. This method of making the plate is by no

bedding in to the lower side of the teeth, then the other half of the pattern must be put on. The middle part of the box is then rammed up and parted, following with the top side which in casting will be the drag side. Taking off this side we next turn our attention to the rapping of the pattern, to be carefully carried out so as not to detach any part of the mould with the teeth. This half of the pattern is then withdrawn and the box turned over, the fellow side of box being lifted, the other half of pattern taken out, and the mould prepared for casting. I need hardly say that for such a pinion or worm wheel great care is required to get good results. A two-parted box can be used, the centre part of mould being rammed up and round the pattern, as a loose core is in making of sheaves and pulleys.

Figs. 2 and 3 show a specially constructed machine for producing small gears of an exceptional character, as used in governor work; the resulting castings are extremely fine, even on leaving the sand.

The spindles and wheel patterns are shown in the illustrations (A, B, and C, Fig. 2), ready for the moulds to be rammed up. Fig. 3 shows the patterns withdrawn. To explain, when the box part is first put on and rammed up, facing sand is carefully prepared and sieved round the patterns, then by a few turns of the wheel that is underneath, the wheels and spindles are withdrawn. In the case of the worm spindles these are withdrawn by the rotation of same, as owing to these having a thread it would be impossible to simply withdraw by the usual stripping plate without rotating at the same time.

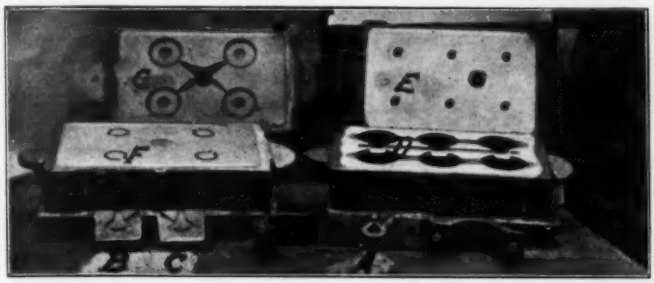

FIG. 3.

Many experts in moulding matters would, I venture to say, be not a little surprised to see the product of these little machines, and would be loth to give the credit due without first seeing the accuracy of the castings produced.

There will be seen illustrated also the plate that contains the prints for the cores (C, Fig. 2), that are to be laid in. These cores are made in green sand from the core box (A, Fig. 3), and when made and inserted are so placed as to leave a thumb piece to the spindle casting, this being made in conjunction. B and C (Fig. 3) show this in its several parts. These are put together and placed in the part of mould shown (D), and are then placed upon the floor. The runners, etc., can also be seen. The side of mould shown in E is next closed upon its fellow, making the mould complete for the spindles, which in this case are six in number. Sometimes there are more or less, according to the size of work and the capacity of the mould, though for a good number of these one standard size of box or mould is used.

Lastly, F and G will be found to correspond in fitting together to produce the small worm wheel.

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"BURNING" A PROPELLER WHEEL BLADE.*

By Thos. D. West, Sharpsville, Pa.

The ability to unite broken bodies of cast iron so as to make the whole as good as when new will not only often save the cost of a new casting, but in many cases may save much machining. To these advantages should be added that of being able to replace the piece quickly, thus saving the heavy losses resulting from the partial or complete stopping of a plant. Of late years several new methods have been established whereby broken castings are united by brazing or by high heat generated by electricity or gases, but beyond what may be done with Thermit these methods do not accomplish what "burning" in the foundry can do with difficult jobs.

Few operations in the foundry require for their successful carrying out greater ingenuity and the constant maintenance of right conditions. The illustration shows a job done at the Mobile Pulley and Machine Works, Mobile, Ala. The foundry foreman, Mr. G. Boys, designed the rigging and supervised the work.

The first step was to make a light loam plate, *c*, Figs. 2 and 4, about 5 in. wide, and a few inches longer than the

* Read before the Philadelphia Foundrymen's Association, September, 1908.

width of the blade, as shown. This plate was made with a curve to agree nearly with that of the under side of the blade at the section to be burnt. The plate was daubed up with loam for about ½ in. above the top of its surface, and then pressed up against the oiled surface of a perfect or unbroken blade, at a point to agree with the broken section. When removed it was finished, blackened, and placed in an oven to be thoroughly dried and await its replacing, as will be described later.

A hole was then dug in the shop floor under the sweep of a crane and the wheel placed in it so as to have a good blade with the tips corresponding with the

FIG. 1.

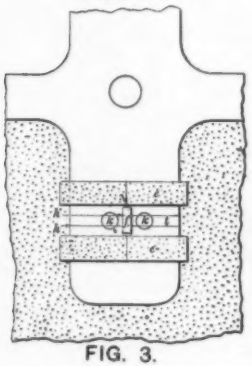
FIG. 3.

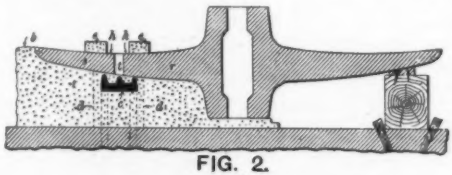
FIG. 2.

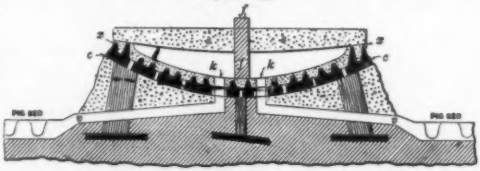
FIG. 4.

FIG. 5.

SECTIONS ILLUSTRATING THE METHOD OF PREPARING THE MOULD AND INTRODUCING THE HOT METAL.

sections to be burned, to be nearly level, as shown at *b b*, Fig. 1. This good section was to serve as a pattern. The wheel was placed as to bring the section to be mended about 18 in. above the general level of the floor. When placed in the hole the four blades were blocked up and staked so that the broken section could be turned to accurately replace the good one. This done, damp tempered moulding sand was rammed up under a good blade and a joint formed at the level *b b*, Figs. 1 and 2, after which a cope was rammed up and lifted off to permit hoisting up and turning the wheel so that the broken blade might lie in the mould formed by the good blade as at *r*, Fig. 2. An iron plate not shown was placed under the hub to form a solid bearing to help support the wheel.

Flat cores ½ in. in thickness were then placed against the face of the broken fracture, which had been chipped fairly even before setting it in position. The ½-in. cores in place and the mould finished, the cope was closed and the mould poured to give the outer end section *s*, Fig. 2, of the broken blade that had been lost. The next day, after casting this end piece, the top body was all cleaned off and the ½ in. thickness dividing cores removed. A narrow channel under this section, about 8 in. wide, as at the lines *d d*, Fig. 2, was also dug out. A wood fire was then started underneath and on top of the section to be united. When both parts were thus heated to a good red heat, the wood and ashes were all withdrawn. The loamed plate *c* being at hand was placed tightly up under the two sections of the blade and the channel *d d* then rammed up around the blocking to hold the plate in place. This is shown in Fig. 4.

Cores at *e e*, Figs. 2 and 4, were placed so as to be back from the ½-in. opening, *t*, Figs. 2 and 3, about 1½ in. on each side. Another core was then placed to form a division as at *f*, Figs. 3 and 4, and all these cores were weighted down so that they could not be moved by the washing or lifting force of the metal.

All this work was done with the ut-

most despatch, and when completed about 1,200 lbs. of good hot metal was poured at such a height as to form a good cutting stream along each edge *h h*, Fig. 2 and 3. The metal as it was poured in was allowed to flow out through a 1½-in. hole in the bottom, as shown at *k*, Figs. 3 and 4, into a pig-bed placed at a convenient distance from the wheel, as in Fig. 4. After this 1,200 lbs. of iron had been allowed to flow through the holes *k*, it was "botted" or closed up at the ends *v*, Fig. 4, and about 500 lbs. of the metal from the ladle was allowed to drop with a cutting force along the upper edges of *h h*, but instead of allowing this to flow away through the bottom holes *k* it was permitted to flow over the top edge *x*, Fig. 4, of the body being burned.

This total of 1,700 lbs. of hot metal cut the ½-in. opening to make it about 2 in. wide. To know of the cutting action and to be able to control it a bent rod or scraper was used to work in the opening between the two bodies to be mended.

The first section on the right hand of the dividing core *f*, Figs. 3 and 4, having been burned and completed as just described, a fresh ladle of hot metal was brought up and left-hand side treated in the same manner.

Mr. Boys has not stated how he removed the dividing core *f* before proceeding with the left-hand burning. This could be readily removed at the proper time by having it well rodded and a hook in it. It is to be understood that in the second operation of burning the metal was allowed to cut into the division formed by the core *f*, as well as along the edge *h h*, and before starting to burn the right-hand side, the left was covered with a plate to prevent metal splashing into its mould space.

It might be well to state that the reason for using the dried loam prickered plate *c*, Figs. 2 and 4, is to prevent the dropping stream of metal from scabbing or cutting up the bottom of the mould, as would very quickly occur in the case of green sand. Instead of using a cast-iron prickered plate, as shown at *c*, a piece of bent boiler plate, 5 in. wide and a little longer than the width of the blade was that actually used. Its concave side was clay washed and plastered with a good thickness of soft loam, after which the work was proceeded with the same as described for the prickered plate.

The reason for putting in the dividing core *f*, Figs. 3 and 4, and only burning one-half at a time, was the possibility of not making a successful union the whole width of the blade were this attempted. By taking only half the width at one time the cutting stream did not have so far to travel, thereby reducing the chance for one section or some points to cool off beyond the semi-molten condition that was necessary in order to ensure a perfect weld.

In a later explanation of the processes employed, Mr. Boys states that after the metal had set in each section, he covered it with a little sand, and forming a bed, poured about 200 lbs. of metal right over the burned portions for about 18 in. wide, and extending well over the ends of the blade. This helped to make the parts adjacent to the burned portions very hot and allowed them to cool off about equal to the new metal, which would naturally pull away from the cold body. After thus covering the top with a hot body of liquid metal, a hole was dug out underneath the burned part to ascertain if this were still red hot, and it was found as was desired. Had it not been red hot a channel would have been made clear in under the blade and a body of metal poured in the channel to come up close to the under side of the blade, thereby keeping the latter red hot in harmony with what was to be expected in a high temperature at the top. The hot scrap metal and the wheel were not disturbed until the morning following the burning operation. After the wheel was removed from its bed to be chipped and cleaned, it had a surface projection somewhat like that seen at *p*, Fig. 5. This had to be all "flogged" and chipped off to give the wheel a finished face.

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A RECEIVING order has been made in connection with the affairs of Mr. T. H. Hill, ironfounder, of the Bow Foundry, Bow, and Enfield, London, N., who traded as Henry Edie & Company.

HASSALL & SINGLETON, LIMITED, of the Phœnix Foundry, Freeman Street, Birmingham, have purchased from the Receiver of Wright & Butler, Limited, their oil boiling and stove department, including plates, pattern blocks, etc.

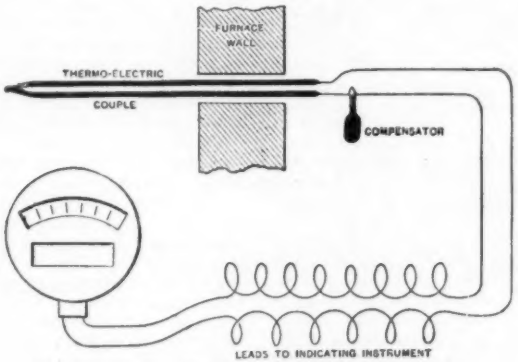
HADFIELD'S STEEL FOUNDRY COMPANY, LIMITED, of the East Hecla Works, Sheffield, have received an order from the London County Council of the value of £22,000 for special tramway work.

LOW-RESISTANCE THERMO-ELECTRIC PYROMETER.

A FORM of thermo-electric pyrometer, which is claimed to be inexpensive, accurate, simple and easily adaptable to all the different uses where such an instrument may be required, was recently described by Professor Wm. H. Bristol of the Stevens Institute of Technology.

Practically all thermo-electric pyrometers in use up to the present time have been of the high-resistance type, using rare metals for the couple, which requires a high degree of uniformity of material. The result is a very delicate and expensive instrument, which is easily injured if subjected to the rough usage of common shop practice. Professor Bristol's instrument makes use of a comparatively low-resistance indicating instrument and alloys of some of the common metals in the construction of the couple. Alloys of tungsten, steel, nickel, iron and copper are used, varying in composition according to the maximum temperature and the indicator used. The entire apparatus consists of three parts—the couple, the leads, and the indicator. The couple is made in two sections, fastened by a screw connection. By this means, one indicator and set of leads will serve for any number of couples which may be permanently left in place, and an injured couple can be replaced at a low cost. The two sides of the circuit are insulated from each other by winding each with an asbestos cord and applying a coating of carborundum paint. When the couple is used for determining the temperature of molten metal, without the protection of an iron pipe casing which is sometimes used, there need not necessarily be a physical connection at the hot joint, as the molten metal will act as a conductor. In all other cases the joint is formed by twisting and electrically welding the ends of the two alloys together.

One of the great disadvantages in most thermo-electric pyrometers, is the difficulty met with in maintaining a constant temperature at the cold end of the couple, and the consequent liability of error in the temperature readings. Professor Bristol has overcome these difficulties by inventing a very ingenious and simple device, which compensates for any variation in the temperature of the cold end by automatically varying the resistance of the circuit. The compensator, as shown in the annexed cut, consists of a small glass bulb having two wires fused into the top and connected on the inside by a loop of platinum wire, suspended in the mercury with which the bulb is partially filled. This is connected in series with one side of the circuit and at the cold end of the couple. An increase in the temperature of this end will cause an expansion of the mercury, short circuiting more of the platinum loop, with a consequent decrease in the resistance of the circuit.



INDICATOR FOR THERMO-ELECTRIC PYROMETER.

The indicator used is a specially designed instrument made with scales of different ranges. Among the several styles in use are a vertical dial switchboard instrument, and a portable instrument arranged in a convenient case. By the substitution of different fixed resistances, any one instrument may be used to indicate a wide range of temperatures.

BRITISH FOUNDRYMEN'S ASSOCIATION.

Sheffield Branch.

At the first general meeting of the Sheffield and District Branch of the British Foundrymen's Association, held in the Sheffield University on October 31, Mr. Herbert Pilkington, M.Inst.C.E., was elected President. Messrs. Percy Longmuir, B.Met., and George Addy, M.Inst.M.E., were elected Vice-Presidents. Mr. Thomas Swinden, B.Met., accepted the position of Hon. Secretary, and Mr. W. F. Bagnall that of Hon. Treasurer. Messrs. J. G. Crowther and R. W. Kemlo will act as Auditors. The Committee consists of the following gentlemen:—Messrs. Allbut, H. Bagnall, Breakey, Firth, Hatfield, Houghton, Peach, Phillips, Sykes, and Mainwaring, together with the above-mentioned officers.

Mr. Pilkington then read his

Presidential Address.

Gentlemen,—In welcoming you to the second session of the Sheffield Branch of the British Foundrymen's Association I feel sure that, successful as the first session was, we shall be infinitely more prosperous in the present one. The record of last year is one, I venture to say, which could not be surpassed by Associations much older than ourselves. We have had papers read by Professor MacWilliam twice, Mr. Buchanan, Professor Turner, Mr. Longmuir, and Mr. F. J. Cook. This is, indeed, a very good commencement for the Sheffield Branch, and I have no doubt that the reputation thus acquired will be sustained. It is, however, important that not only should we have papers for discussion, but that also we should have discussions on practical matters themselves without necessarily demanding a formal paper for their production, and I express the hope that members will come forward and offer their services in this direction. We are essentially an educational institution, and such discussions, initiated by anyone who has any foundry subject to bring forward, can only be productive of good results. We have been extremely fortunate in securing the services of Mr. Thos. Swinden, Bachelor of Metallurgy, as Hon. Secretary, and as you are all aware, the success of an Association materially depends upon its secretary. I think that Mr. Swinden, who is a young man of considerable scientific attainments, will be able to materially assist this Branch in its labours, not only on the scientific side but also in practical organisation. The Central Association, as you are all aware, is exceedingly prosperous, and its numbers are increasing most rapidly, but I suggest to you that the real strength will always remain with the local Branches, and I trust the day will soon arrive when the full proceedings of all the Branches can be incorporated in the proceedings of the Central Association. It is a curious fact that in all cases the more practical papers and discussions have taken place at these Branch Associations, and the reason is not far to seek. I think if the practical members would, shall I say, shake off their shyness and initiate or take part in the discussions, we should more rapidly attain the object which the Association seeks to promote.

In making a Presidential address, I have therefore determined to take the subject of "Foundry Pig-iron Specifications," with which for a considerable part of my life I have been concerned. Primarily as a pig-iron maker, I have always been more or less associated with foundry work, and also with the conversion of pig-iron into finished iron and steel.

Foundry Pig-iron Specifications.

One of the characteristics in which the Americans most excelled is the question of standard specifications of all sorts. There is, however, in America no Great George Street, Westminster, nor is there any equivalent for it there, and so far as the subject of foundry pig-iron is concerned, the whole circumstances of the two countries are widely different. Practically the whole of the foundry pig-irons in America are made from hematites of one class or another, while those of this country have nothing whatsoever to do with hematites, and those iron founders who do use hematites occasionally are mostly sorry for it afterwards. The circumstances of American produce, as a general rule, comparatively low-silicon irons, while in this country the silicons are considerably higher. From the point of view of a maker of pig-iron I have carefully considered specifications produced by American Associations, and all I can say is that they have little application on this side of the water. Chilled castings—such as rolls and car wheels—are made in America from so-called charcoal hematites, while in this country we use certain pig-irons containing up to 0.5 per cent. phosphorus for such purposes, with infinitely superior results. Indeed, both from the question of crude pig-iron, methods of moulding, methods of melting, and the whole question of the working foundry, after a considerable study both from visits

over there and from their literature, I do not feel, from the British iron-founders' point of view, any special respect for their methods.

British Advantages.

It is a most curious fact, notwithstanding their comparatively low silicons, that American castings, no matter for what purpose they are intended, are all decidedly soft, for reasons which are due to the natural supplies of ore of that country. Therefore we in this country can, for once in a way, take a little credit for the fact that for the most part we are able to find materials, in the shape of ores and pig-iron, which will fulfil the extreme conditions between, say, chilled rolls or castings on the one hand and very soft iron for machining on the other; or dense iron which is required for, say, motor cylinders on the one hand, and the intricate artistic castings for ornamental purposes on the other. Therefore, on the whole I regard the American pig-iron specifications as altogether unapplicable to this country. It is utterly impossible in any pig-iron specifications to ignore commercial and practical facts, and foundries that work on certain chemical mixtures are bound to be governed in their supplies largely by what they can obtain in an economical and reasonable way. Nevertheless, cases are not infrequent where foundries set up for themselves an ideal "mixture" for their particular work, and then purchase it in a most wasteful and uneconomical way, probably without any knowledge as to the more easy and cheaper way to attain their object.

British Shortcomings.

It is manifest that certain districts will make a certain general class of pig-iron. At Frodingham, for instance, irons can be little varied in their composition, because the materials available there are the cause of the resulting composition of the pig-iron. The same illustration holds good in Middlesbrough, Derbyshire, North Staffordshire, and Northamptonshire. Generally speaking, the pig-irons from these several districts are purchased with practically known compositions, and at a price common to each works in the district, while the only variable chemical element in these districts is the silicon. In South Staffordshire the situation is somewhat different, inasmuch as various special irons are made there. Their supply of raw material leads to this specialisation, and each brand must be taken on its own merits. Indeed, some of these brands live more on past reputations than present values.

As both a maker and user of foundry pig-iron, nothing has more impressed me than the comparative ignorance of foundrymen upon the subject of pig-iron quality, and I do not know that the situation has much improved since the chemist appeared on the scene; hence I have frankly come to the conclusion that until a new generation arises which knows not the old Joseph, things will not be much altered. This is a question of *personnel* which, of course, time will correct, but the real trouble is that neither the chemist nor the foundryman has ever properly realised the physical side of pig-iron sampling. It has been rashly assumed by many foundry managers and their chemists that because such iron as basic pig-iron for steel making can be made "within limits," to a definite composition, the same thing can be done with foundry grades of pig-iron. This is far from being the case. In basic pig-iron the carbon is practically all in solution and in foundry pig-iron nearly the whole of it is out of solution. In basic pig-iron the silicon is very low, and in foundry pig-iron it is very high. The composition of basic pig-iron is altered very little by casting it into pigs at the furnaces and its subsequent cooling down, while this same operation with regard to foundry pig-iron changes it both chemically and physically. In the sale of either hematite or basic pig-iron for steel making no questions of grain, grade, hardness or even any physical characteristics are raised, but in foundry pig-iron and in the resulting castings the grain, grade and relative hardness have very much to do indeed with its strength and soundness, while within limits its composition may very safely vary. For the sake of illustration, you would not make a soft casting, intended to take much machining with white pig-iron, neither would you attempt to make a chilled roll with a rich No. 1 pig-iron. These illustrations are purposely extreme ones, but in all castings the questions of grade and grain have always been vital and important matters, and certainly always will be. Furnacemen have always been fully conversant with the fact that the varying temperatures at which pig-iron leaves the tapping hole of the furnace has a powerful effect on its physical characteristics. The temperature of a large modern blast furnace is very much higher, and the metal therefore takes very much longer to cool than that which leaves the tapping hole of the smaller furnaces. Pig-iron from these ex-

treme types could be made practically alike in chemical composition, but would behave physically in a different manner altogether, and would show very different grades, grains, and degrees of hardness.

An illustration of these questions of grain and grade may be taken from the foundry itself. The chemical composition of the iron in a separately cast test bar capable of withstanding 3,000 lbs. transverse stress may be known, and may under precisely similar conditions be indefinitely reproduced with a certainty of withstanding the test. If, however, you take a large ladle of iron of the same composition and cast it into a large casting having the test bar cast on to it, that test bar when broken off and tested will inevitably fail to come up to the strength of the separately cast bar, even if the iron is from the same ladle. It is, of course, quite obvious that if you cast from the same ladle an ordinary test bar 2 in. by 1 in., and then cast a casting 12 in. square, the physical characteristics will be absolutely different. These are well-known facts, and are simply used to show that the finished casting must be placed on a different footing altogether.

Improved Grading Methods.

A great many of the practical facts connected with that aspect of casting were known long before the science of micrography was established, and although that science has thrown a flood of light upon the subject it is but the development and study of the crystallisation, or grain, in pig-iron or castings, which is produced as a result of certain heat conditions. To a very large extent that has proved the necessity and value of grading pig-iron by fracture, and that, after all, is a somewhat crude method when the classification is done by numbers alone. It is palpable, therefore, that some improved method of grading is in every way desirable seeing that fracture of itself is an unreliable guide to a definite behaviour. In all suggested chemical specifications none are free from some practical objection or other, and very frequently their authors failed entirely to appreciate the commercial elements of the situation. It is my own opinion that classification by fracture cannot be wholly abandoned until some method of physical or microscopical classification is introduced to replace it, which will no doubt be the case some day. This will at the same time not entail any abandonment of chemical analysis to complete the classification, but will rather be its aid. That time, owing to practical and commercial reasons, and also the time necessary to educate their people, is not likely to arrive within a reasonable period. It is fairly obvious, therefore, that under these several conditions the only practical step in advance which can be taken at the present time is one indeed which is very largely coming into vogue—viz., to continue the present method of grading by fracture numbers and sell the "pigs" on their silicon contents for that particular number.

In America, with their comparatively low silicons, it has led to increased prices actually being paid for the higher silicon irons. This method of sampling foundry iron, which is a distinct step in advance, of course, assumes that the character of the particular brand of iron is known; that is to say, that taking the different districts the phosphorus and manganese in these known brands would be practically constant, as well as the total carbon content. The only variable elements therefore would be silicon, sulphur and combined carbon. In my opinion this double method of grading by fracture and silicon content would effectually stereotype a definite percentage of sulphur in all the grades, and although there are known instances of variation, such as white iron, they are only of minor importance. By this method of sampling also it will be found that the content of combined carbon, which after all is the most important constituent, will vary very little in a known brand of iron.

The specification of silicon alone is utterly useless for the purpose of grading foundry pig-irons, as is also the specification of silicon and sulphur without the fracture grade. Innumerable instances of this might be quoted, but perhaps the best illustration is that of the material known as glazed or silky forge pig-iron, which contains a high percentage of sulphur as well as silicon. This is occasionally produced at blast furnaces when the percentage of lime used for fluxing is inadequate, due to variations in the lime content of the ores. On the other hand, what is known as foundry silky pig-iron while having an extremely low percentage of sulphur has, of course, high silicon, so it is clear that in everyday practice high silicon may be present in both hard and soft irons of the same brands. That low silicon and low sulphur exist together in the same pig-iron is well known, as in the case of basic pig-iron, but it is perhaps not so well known that rich overgrey pig-iron may be frequently produced extremely low in sulphur, containing practically none at all, with very low silicon. This iron may be

readily detected by its scattered chilled fracture. It is extremely hard, will not carry scrap when melted in a cupola, and is characterised by very high combined carbons, sometimes amounting to 1 per cent., while the silicon will be under 1½ per cent.

These fluctuations between high silicons and high sulphurs in one pig and low silicons and low sulphurs in another pig, and "their various graduations" are of more frequent occurrence than is generally appreciated, and too much reliance is placed by foundry iron consumers upon the particular analysis they receive, which frequently only represents the particular piece of pig-iron subjected to analysis, and is therefore by no means representative of the whole bulk. This is due to the very practical difficulty of properly sampling such irons. The quantity of silicon will often vary as much as 1 per cent. in the same cast, and it may be broadly stated that the first iron run from the blast furnace, which has the furthest to run to the bottom of the pig beds, is the lowest in silicon, while near the middle of the cast the highest silicon will be found. The nose end of the pig is lower in silicon than the sow from which it was broken.

In the case of sulphur, as a rule the quantity varies in the same cast in an inverse ratio to the silicon, if there are no other disturbing elements.

The percentage of combined carbon in a known brand of pig-iron, however, is, after all, the subject of greatest importance to foundrymen, as it is the ultimate measure to a very large extent, other things being constant, of the hardness or softness or strength of the iron. Assuming that the percentages of phosphorus, manganese, and sulphur are normal, the percentage of combined carbon is independently subject to the influence of the percentage of silicon which it contains, and also to the temperature at which it leaves the furnace, and the rate at which it cools in the pig beds. Suppose we were to assume a similar silicon content in the pig-iron produced by two different plants, one of these being a large fast-driven blast furnace and the other only slowly operated; the actual temperature of the iron cast from the former would be very much higher than that of the latter. It would also be found that the combined carbon of the one would materially differ from the other, although each would differ in the different parts of its own cast, as I have previously pointed out. This difference is entirely due to the one iron having to cool down from a higher casting temperature than that of the other. There is also some variation due to the different character assumed by the combined carbon itself in cooling, and this point is one which requires considerable patient investigation on the part of metallurgists, which, so far as I am aware, it has not yet received. In practice, however, under normal conditions, these actions are modified by the content of silicon, which, according to its percentage, controls the formation of combined carbon to a large extent. It follows, therefore, I contend, that foundry iron should be graded by the percentage of silicon contained in each number as graded by fracture. Thus, a selection of iron required for a particular purpose in the foundry would be made by the selection of the make of a certain district or particular brand to secure the proper amount of phosphorus and manganese required, and the constancy of these could by this rule be well relied upon. The iron would be graded by fracture and that number would be sold with a definite percentage of silicon content. This appears to me to be the rational way of dealing with this very vexed question at present, and at all events it would be the first step to place grading on a more satisfactory basis.

It must not be forgotten that all these changes resulting from physical temperature and silicon content can occur in just the same manner in remelting the iron in the cupola or other furnace, and it is of the highest importance that all remeltings should be done with a sufficiently high temperature and with sufficient silicon to let all the carbon changes have full play. In melting in an air furnace or a Siemens furnace this is no doubt accomplished, but it very frequently happens, however, in cupola melting, which is often done at an insufficient temperature, that this is not accomplished, with the result that the iron contains more sulphur, and what is frequently infinitely worse, more combined carbon. The results are often rendered still worse, however, by the metal standing too long in the ladle before casting.

In remarking upon this subject, I do not desire to reflect in any way upon the valuable services that the chemist has rendered both at the blast furnaces and in the foundry. His services are too well known and of too valuable a character to require further mention. My object is to point out an easily available way to deal with the subject. Until iron-founders have attained the same plane of knowledge with regard to pig-iron as the makers

of it have, and until both are in a position to get proper micrographic analyses, as well as chemical analyses—the science of micrography still being in its infancy—we must continue to use those methods of grading which are most readily available and reliable. But the day is not far distant when research will elucidate the obscurities of the whole subject.

At the conclusion of the address, with Mr. Pilkington's kind acquiescence, the subject was thrown open for discussion. The discussion proved extremely interesting, resting chiefly on the use of hematites in the foundry.

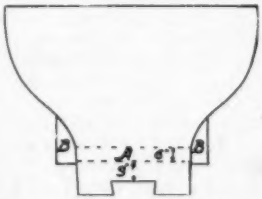
With the President's reply the proceedings terminated.

——o——

SMALL CORES THROUGH THICK METAL.

By J. McC.

Recently the author cast two anvil blocks each weighing about 32 tons, and with a 6-in. diameter core running through A (see illustration), having 9 in. of metal on the bottom, and considerably more on the sides and top. With the first



Cores through Thick Metal.

one cast the core was made of three parts Erith sand and one part old loam; but when the core came to be cleaned out it was like cutting into solid metal. To overcome this trouble, 8-in. prints were put on at B B, and a straight piece of pipe 6 in. inside diameter and 1 in. thick, cleaned and rammed full of Erith sand was cast in, giving a splendidly clean hole in casting. Since then the author's procedure when a round core is required running through thick metal not to be drilled, is to procure a pipe, malleable or cast, and ram it full of sand. No trouble in regard to vents, scabbing or cores breaking is experienced; and practically no cleaning is needed. For smaller work it is an advantage to coat with paraffin and red lead.

THE "FOUNDRY TRADE JOURNAL" BOOKSHELF.

Practical Metallurgy.

By Thomas Turner, M.Sc., A.R.S.M., F.I.C.

This little book has been compiled for use in connection with the course of study for the Degree of Batchelor of Science in Metallurgy in the University of Birmingham. The object of the experiments dealt with is to give the student the opportunity of becoming better acquainted with the various materials and products with which the metallurgist has to do. Commencing with the sampling and weighing of materials, the author proceeds to describe the methods of preparing test samples of metals and alloys. The oxidation and reduction of ores is briefly described, as also is the examination of fireclay and the production of crucibles. Following this the various subjects with which the student is required to be familiar—slags and fluxes, the examination of fuels, the examination of iron ores, muffle temperatures, silver and gold assay, etc.—are treated, the experiments being described in a brief and practical manner, suitable to the nature of the book. It is intended to cover the first two years of laboratory work, and will be found to meet the requirements; the subsequent work of the student would require the fuller standard manuals of the laboratory.

The publishers are:—Messrs. Charles Griffin & Company, Limited, Exeter Street, Strand, W.C.

Electric Furnaces.

By Wilhelm Borchers.

This is an English version of the German edition of "Die Elektrischen Ofen," by the author, who is a well-known authority on electrc-metallurgy. The book includes descriptions of almost every variety of electric furnace in practical use, particularly the latest and most successful of those used on the Continent. As an example of this may be quoted the inclusion of the Girod resistance-arc furnace, which ranks as one of the latest of the successful furnaces. The method of treatment and classification adopted is from the point of view of the heating system on which the action of the furnaces is based, and, further, their development and application are examined and criticised. Opening with an introduction on methods of heating, the author proceeds to describe furnaces working on the

principle of direct-resistance heating, *i.e.*, the substance to be heated itself forming the heating resistance. Then follows indirect resistance heating, where the material to be heated is in contact with an electrically-heated substance, direct arc heating in which the substance to be heated forms one or both poles of an arc, and indirect arc heating and radiation furnaces. The various furnaces in the different classes are described and their peculiar fixtures indicated, while in a further chapter, on the construction of electric furnaces, this subject is dealt with more fully as regards general detail. The application of electric furnaces and furnace output give material for two very instructive chapters, including some useful information in the way of recorded results.

The recent rapid development of the electric furnace has given a decided stimulus to the interest displayed in the subject, for undoubtedly an important future lies before it in connection with all metallurgical operations. In the foundry, certainly, it has not yet become at all prominent, but in view of what Continental users are doing, the subject can profitably be given more attention. As a comprehensive survey of furnace construction this book will appeal to all who take the matter up.

The publishers are:—Messrs. Longmans, Green & Company, 39, Paternoster Row, London, E.C.

—o—

QUERIES.

Foundry Recovery Plant.

Recently we have put down a foundry recovery plant for recovering the iron and coke in the cupola slag, the chips from the dressing shop floors, and the metal, iron, and coke from all the various kinds of reddings in a foundry. A large proportion of the iron that is recovered from the cupola slag is in the form of round balls or shot, of various sizes, bright and clean when they come out of the recovering mill. These, we have thought, might be better utilised than by melting them up in the cupola again, the way we are doing at present, and we should be glad of an expression of opinion or any useful information on the subject from your readers. Could the balls be used for filling shells or anything of that kind?

"FOUNDRY PROGRESS."

NEW COMPANIES.

HALE & COMPANY, LIMITED.—Capital £500, to carry on the business of ironfounders, etc.

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ROBERT MACLAREN & COMPANY, LIMITED.—Capital £150,000, to acquire the business of Robert Maclaren & Company, Eglinton Foundry, Port Eglinton, Glasgow.

MIDLAND IRON WORKS (NEWARK), LIMITED.—Capital £3,000, to acquire the business of J. S. Hall & Company, Limited. Registered office: Kelham, Newark-on-Trent.

PASCALL, ATKEY & SON, LIMITED.—Capital £20,000, to acquire the business of marine engineers, ironfounders, etc., carried on by Pascall, Atkey & Son, at Cowes, Isle of Wight.

HERBERT SMETHURST & COMPANY, LIMITED.—Capital £2,000 in £5 shares, to acquire the engineering business of Herbert Smethurst & Company, Butler Green Metal Works, Hollinwood.

KLEIN ENGINEERING COMPANY (1908), LIMITED.—Capital £3,000, to take over the business of the Klein Engineering Company, Limited. Registered office: 94, Market Street, Manchester.

CRESCENT FOUNDRY COMPANY, LIMITED.—Capital £4,000, to acquire the business of an ironfounder, formerly carried on by J. Bailey as James Bailey, Sons & Company, at Crescent Works, Pleck Road, Walsall.

GEO. A. BROWNING & COMPANY, LIMITED.—Capital £5,000, to acquire the business of a manufacturer of engineering and foundry work carried on at Mawney's Road, Romford, Essex, as the Premier Manufacturing and Engineering Company.

—o—

THE late Mr. T. Perkins, of the firm of Messrs. Barford & Perkins, engineers, left estate valued at £87,043 gross.

MR. E. MUMFORD PRESTON, of the Brass, Copper, and Iron Works, Deptford, London, S.E., is the Mayor of Deptford for the ensuing year.

FOUNDRY LADLES.

28 LB.
—to—
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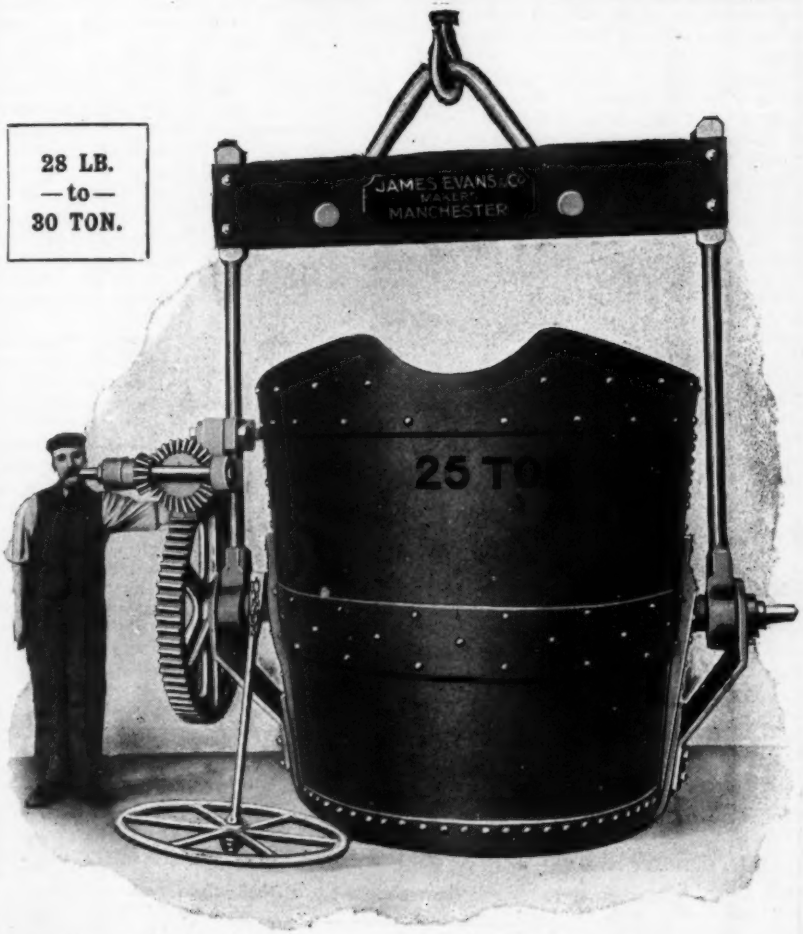

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BLACKFRIARS, MANCHESTER.

DEATHS.

MR. H. CROWTHER, of Henry Crowther & Sons, Limited, engineers, of Cleckheaton, aged 66 years.

MR. H. S. COLEMAN, for many years connected with Messrs. Coleman & Sons, afterwards Coleman & Morton, engineers, of Chelmsford, aged 81 years.

MR. C. ANSON, for the past 33 years representative of Messrs. William Cooke & Company's Steel Works, Tinsley, Sheffield.

SIR WILLIAM B. AVERY, a director of W. & T. Avery, Limited. His connection with W. & T. Avery, Limited, dates back to the year 1881, when he and his brother, Henry J. Avery, assumed control of the undertaking, which was steadily developing its operations. In 1891 the business had increased to so great an extent that it was decided to register it as a private limited company, and when, three years afterwards, Mr. H. J. Avery died. Mr., afterwards Sir William, Avery, Bart., resolved to convert the undertaking into a public company, under the title of W. & T. Avery, Limited. A year or so later, Sir William Avery withdrew from the active control of the business, and resided on his picturesque estate in the Thames Valley. He, however, retained his place on the directorate until his death.

—o—

PERSONAL.

MR. DOUGLAS VICKERS, Master Cutler of Sheffield, is to be invited to stand as the Conservative candidate for the Brightside Division of Sheffield.

MR. J. T. PEDDIE, lately with the Birmingham Small Arms Company, has been appointed to a position with Vickers, Sons & Maxim, Limited.

MR. DAVIDGE PAGE has resigned the position of managing director of the Page Publishing Syndicate, Limited, publishers of "Page's Weekly," owing to continued ill-health.

THE late Mr. G. K. Stothert, senior partner in the late engineering firm of Stothert, Slaughter & Company, and of Messrs. G. K. Stothert & Company, marine engineers, left estate of the gross value of £26,822.

MR. J. T. MIDDLEHAM, of 56, Birkendale, Sheffield, has been appointed secretary of Hadfield's Steel Foundry Company, in succession to Mr. W. H. Dixon, who, it will be remembered, is also a director of the company.

—o—

THE DERBY CHAMPER OF COMMERCE proposes to entertain its ex-President, Mr. Edgar W. Jobson, to a complimentary dinner on December 2. Mr. Jobson is the managing director of the Derwent Foundry, Derby.

THE MIRFIELD ENGINEERING COMPANY, LIMITED, are erecting new works at Nunbrook, Mirfield, to be electrically driven throughout. This has been necessitated by the great expansion in the demand for the Company's hydraulic tools and presses.

MR. HARALD O. MARTINDALE, iron, steel and metal merchant, manufacturer of foundry requisites, etc., of Leith, has found it necessary, by reason of his continually expanding English business, to open an office in Manchester. From this office, which will be under the management of Mr. George Mercer (who has been Mr. Martindale's assistant for several years), all English orders will be executed. The preliminary address is 11, Regent Road, Manchester.

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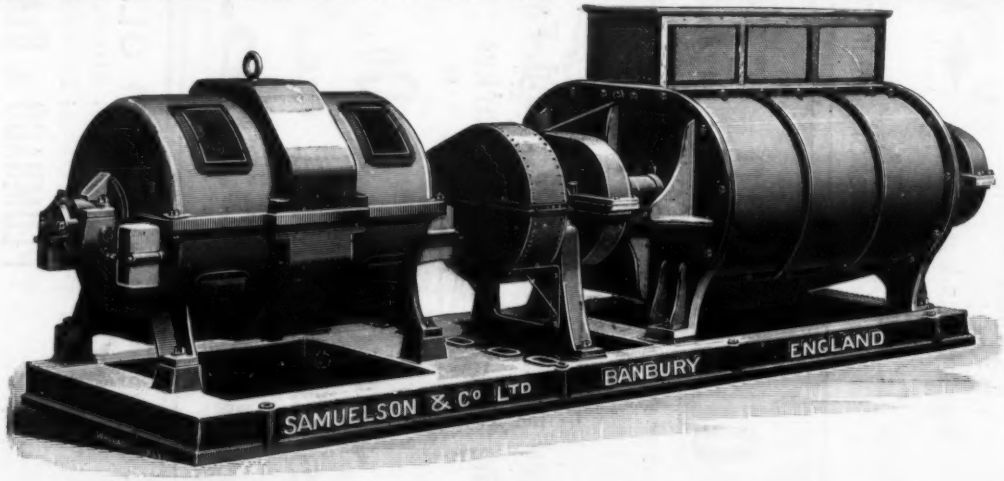

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From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

Metals.	1907-8.	1906-7.
Iron—Scotch pig warrants ... ton	*55 6	*59 6
—Middlesbro' warrants ... ... ton	49/6½	49/4
—W.C. M/nos Bessemer ... ... ton	59/6	68 6
—Stock, Scotch, tons	1,000	1,224
Copper—Chili bars, GMB ... ... ton	£63 15/0	£60 17/6
—Stock, Europe & afloat... ... tons	52,835	15,789
Tin—English ingots ton	£136 0.0	£137 10/0
—Straits ... ton	£135 17/6	£133 15/0
—Stock, Ldn. Hlnd and afloat ... tons	—	12,664
Lead—English pig ton	£13/17 6	£15 5/0
Spelter—Ord. Silesian ... ... ton	£21/6 3	£21 2/6
Quicksilver—(75lb.) bottle	£8 10/0	£8 1/6
Antimony—Regulus ... ... ton	£32 10/0 £34 10/0	£32 0/0-£36 0/0

*Settlement price.

Castings.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 15 0	to	7 0 0
Pipes, 1½ to 2½ in.	5 2 6	to	5 7 6
,, 3 to 4 in.	4 15 0	to	5 5 0
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.	4 12 6	to	4 15 0
,, 18 to 24 in....	4 12 6	to	4 15 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 5 0

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 5s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 6s. 0d.; all per ton f.o.b., London. Copper (clean), £59 0s. 0d.; brass (clean), £41 10s. 0d.; lead (usual draft), £13 0s. 0d.; tea lead, £11 5s. 0d.; zinc, £16 10s. 0d.; all per ton delivered merchant's yard.

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Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

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FOUNDRY EQUIPMENTS,

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Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

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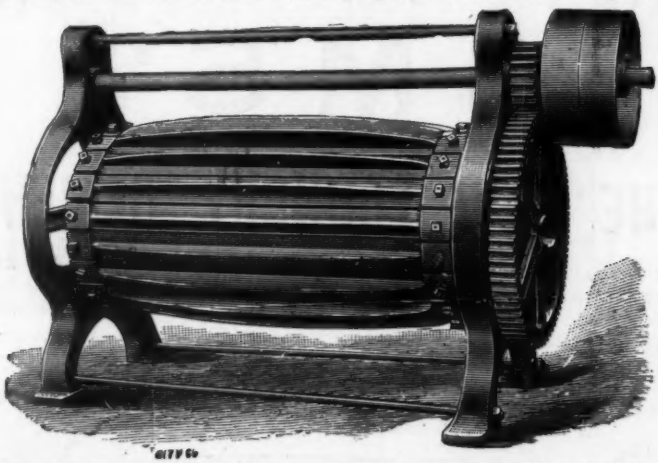

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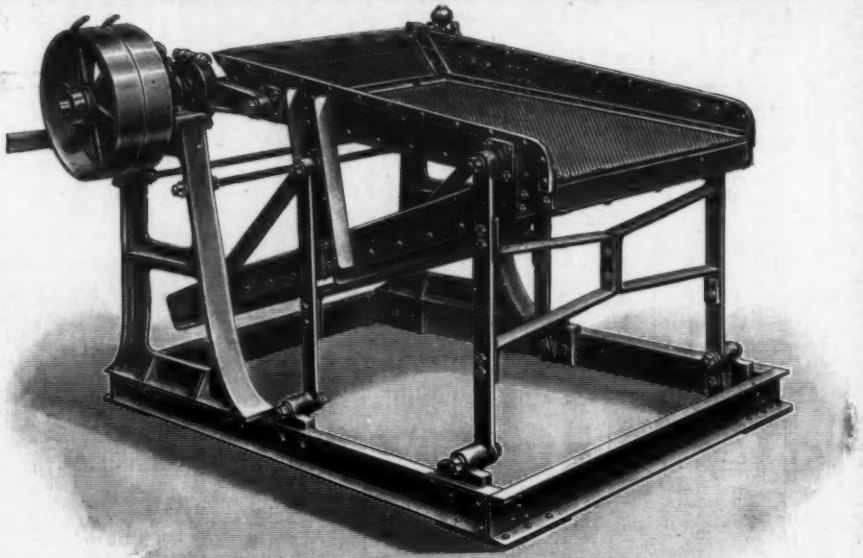

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